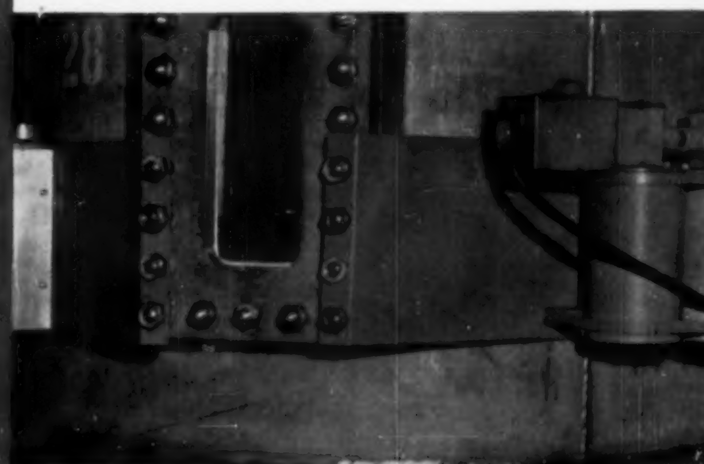
CHEMICAL ENGINEERING PROGRESS

CEP

NOVEMBER 1957

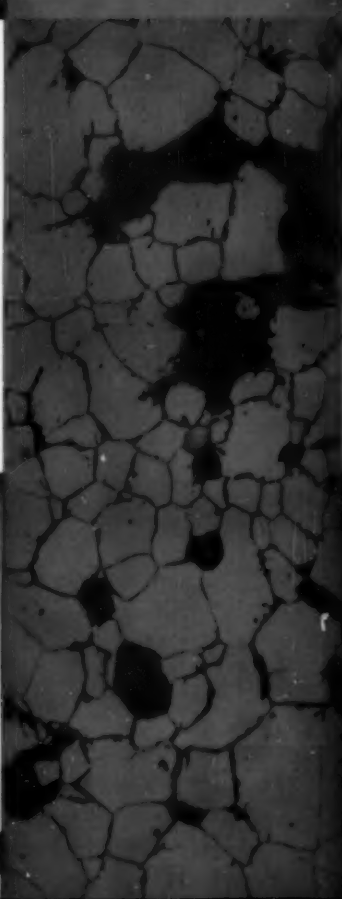
SWAPPING PROCESS KNOW-HOW

with operating firms abroad offers many advantages, financial as well as technical. It's being done by more and more of our domestic chemical companies.



CHEM SHOW

The 26th Exposition of Chemical Industries will be in New York's famed Coliseum. Here is your guide to what to see, who will be there to talk to.



CORROSION

Where, why, and what to do about corrosion are subjects of wide interest to the chemical engineer. Here is a general resume of the practical side of the problem.

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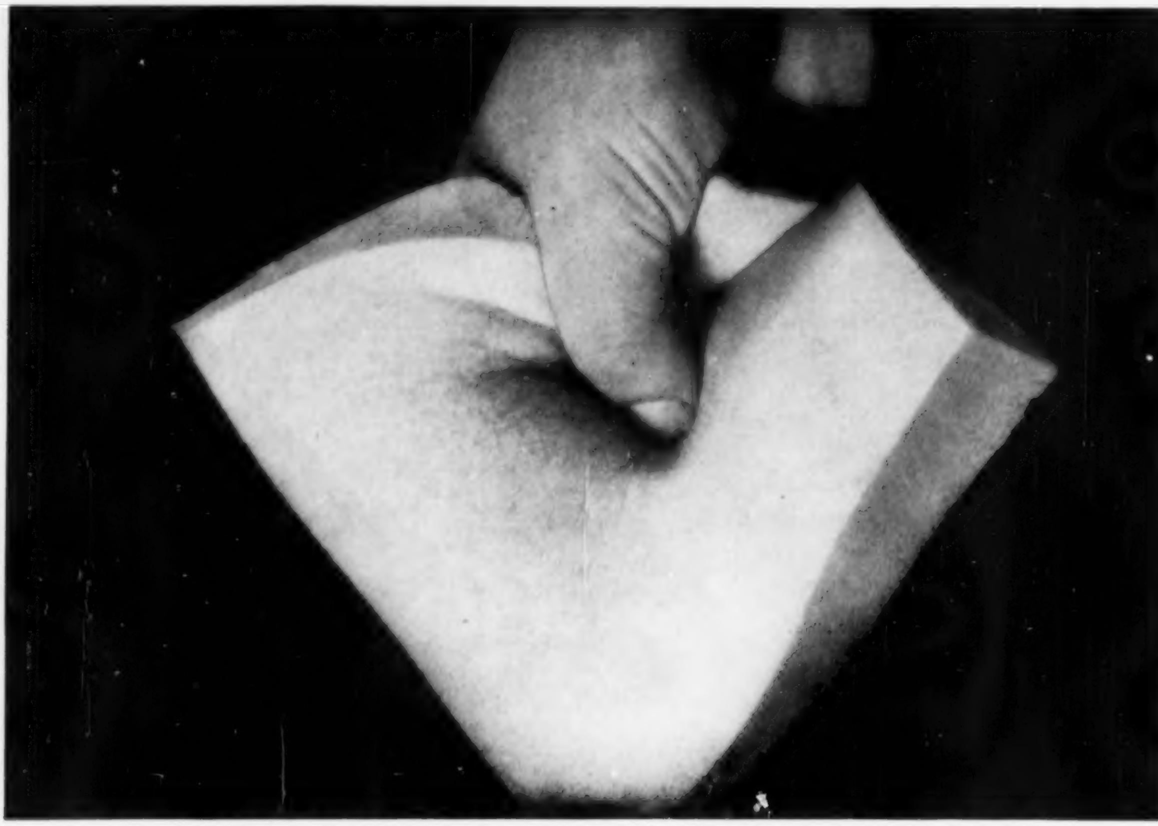
extraction column uses cesium-137 to monitor both extract and raffinate continuously for control of feed rates.

PLUS:

Unity in the engineering profession? • What is the AEC up to? • Notes on adsorption, dialysis, and ion exchange • Trends in soda ash and chlor-alkali • Anhydrous H_2O_2 as propellant • Opsearch in R and D • Estimating labor costs • Ready for disaster? • Air pollution policy • Natural gas and the Northwest.

AND: Author's pix for Chicago Annual Meeting December 8-11.



Chemical Engineering Progress

what's in this issue

November, 1957 • Volume 53, No. 11

Part II will appear next month.

(Continued on page 5)→

departmental features

CLEAN (*99.9% plus) SEPARATION * with YORKMESH DEMISTERS®

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SOLVENT EXTRACTION with YORK-SCHEIBEL LIQUID-LIQUID EXTRACTORS

YORK-SCHEIBEL patented multi-stage extraction columns are manufactured in all sizes, from small laboratory models to the largest production units. YORK engineers with years of experience in solvent extraction are prepared to recommend or develop the best design for your conditions and requirements.

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- ☐ **Bltn. #1001** - A case study of the capacity increase obtained by the use of a Yorkmesh Demister in a refinery vacuum tower.
- ☐ **Bltn. #1005** - Case studies on decreasing compressor maintenance problems by the use of Yorkmesh Demisters in compressor suction drums.
- ☐ **Bltn. #23** - General description of separator vessels employing Yorkmesh Demisters for removing entrained liquids from steam, gas, and chemical vapor streams.
- ☐ **Bltn. #24** - York-Scheibel extraction equipment. General description of efficient multi-stage extraction columns for performing simple counter-current and fractional liquid extraction operations.
- ☐ **Bltn. #561** - Performance of an Internally Baffled Multi-stage Extraction Column. Horizontal baffles together with mechanical agitators gives columns having very low height equivalent per theoretical stage values.
- ☐ **Bltn. #571** - Bench Scale Liquid Extraction Techniques. Describes basic techniques and equipment employed in the York Laboratory for development of liquid extraction processes.
- ☐ **Bltn. #572** - Economical design of liquid extraction processes - How increasing the number of stages reduces processing costs.

We invite you to see our equipment at the Chemical Exposition, Booth No. 69.

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(Continued from page 3)

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Cover by *Milton Wynne Associates*

HIGHER EDUCATION AND THE NATIONAL WELFARE

Noted and quoted

*Lee A. DuBridge** | President, California Institute of Technology

The Russians have launched an earth satellite and made great progress in rockets and in atomic weapons because they can mobilize their best brains to the service of the state at will. Our best brains are as likely to be found developing television sets, doing research in medicine, running a great automobile factory or chemical company or mercantile business, or pursuing a thousand other opportunities which are available in a free society. This is fine and it is the way we want it. We would utterly reject the idea that all who receive educational opportunities at state expense shall work only for the state. We prefer a free society—and just because our society is free we have been able to produce the wealth to keep it free. And an important part of the task of keeping it free is to feed a tiny fraction of our great wealth back into a first-class educational system which will give all Americans the opportunity to develop their intellectual abilities to the fullest.

* Condensed from an address given on October 14, 1957, before a meeting sponsored by the Advertising Council of America and the Council for Financial Aid to Education.

It is not our idea of democracy to educate a limited number of people and make all of them work for the state. We want to educate many people so there will be enough to work for national welfare as well as for national security.

But here we face a real dilemma. Shall we deny tomorrow's college-age population the opportunities which their parents enjoyed by rejecting a large fraction of the applicants who yesterday would have been considered qualified for admission? Or shall we provide the physical facilities to admit them and then give them such poor teachers that their college years are wasted?

I think that it is not necessary to choose either of these alternatives. We must face frankly and firmly the task of providing educational opportunities for many, but making sure that at least the best of our students are held to educational standards of the highest quality.

If I might venture a political suggestion to help keep control of the situation, it would be this: since not all who vote on school matters pay state income or local property taxes, it would be useful to tie school and college expenditures to a sales tax.

Thus, every voter will know that he will be paying his share of the costs of educating his children. He will then be interested in seeing that schools are adequate but not wasteful.

In all of these discussions of the future of higher education, it is important that we keep in mind the essential contribution that higher education in America makes to national welfare and security. Not all college graduates are exceptionally valuable citizens, and not all leading citizens are college graduates. But more and more in a complex society the men and women who guide the development of our business, political, industrial, technological, and scientific activities are those who have had advanced educational experience.

ATOMIC ENERGY COMMISSION BASIC PHILOSOPHY

*Harold S. Vance** | U. S. Atomic Energy Commission, Idaho Falls, Idaho

There is a misconception or lack of understanding by far too many people of the basic philosophy of the Atomic Energy Commission in its endeavor to promote the peaceful uses of atomic energy.

An example of how far afield this misconception of Commission plans and purposes can go is found in a recent speech of a well-known educator who said in effect that the time has come when the Atomic Energy Commission should be liquidated because of its sinister purposes. Among these sinister purposes he listed the creation of a monopoly in the field of high energy physics, including all of its potential applications; the federal control of education; and, finally, even the nationalization or socialization of industry. If there were the slightest foundation for such assertions, they would be serious indeed.

* From remarks delivered at the Industrial Preview of the Engineering Test Reactor, Idaho Falls, Idaho, October 2, 1957.

As a first step toward making a clear statement of the basic philosophy of the Commission in discharging its statutory responsibilities, particularly as it affects industry and education, it should be pointed out that the Atomic Energy Commission has two major purposes or reasons for its existence. The first of these was the original purpose of the wartime Manhattan District: to design, develop, and manufacture nuclear weapons. That still is the primary and overriding responsibility of the Commission, one upon which I firmly believe the peace and safety of the world depend. The other major objective of the Commission is to promote the development of nuclear energy for peaceful purposes. The importance of this second objective is great, as we all recognize. It is second only to the maintenance of that military strength which guarantees our existence as a nation.

The philosophy of the Commission is quite simple. It is that we should move forward with all the vigor at our command in promoting peaceful uses of atomic energy, that we should do so in a manner which does no violence to our normal way of doing business in America, promoting nothing else of a political, social, or any other nature.

Secrecy

One of the areas in which the Commission has been often misunderstood stems from the interrelation of the two distinct purposes of the Commission which I have just stated. It is the matter of secrecy. There is no clear demarcation between the military and the civilian technical work of the Commission. In matters having to do with military application it is extremely important that the Commission take every possible precaution against the weakening of our national security by allowing important military information to fall into the hands of those who are or could be potential enemies.

There is evidence that the whole body of technical knowledge about nuclear weapons possessed by the Soviet Union did not generate inside its own scientific competence. On the contrary, it is clear that an important

(*Continued on page* 8)

HOW TO SELECT WATER-CONDITIONING EQUIPMENT (NO. 4 OF A SERIES)

Filters

Basic filter parts include: the outside container, the bed of filter medium and the distribution and collection systems to provide a uniform flow through all parts of the bed. Flow rates average 2 to 3 gallons per minute per sq. ft. of bed area.

Filter beds are cleaned periodically by reversing the flow and increasing it to about 10 to 20 gpm per sq. ft. (backwashing). This lifts and swirls the sand, loosening the dirt and flushing it to waste.

Rotary surface washers with high-velocity water jets may be used to help break up the layer of dirt on top of the bed.

After backwashing, the first water through the filter (rinse water) also picks up some dirt and is run to waste.

A "multiport valve" replaces 5 individual valves and reduces the number of valve manipulations for cleaning a filter from 10 to 3. It also indicates the cycle in progress and ensures proper sequence. Operation can be made completely automatic with hydraulically- or motor-operated valves controlled by meters, timers and float switches.

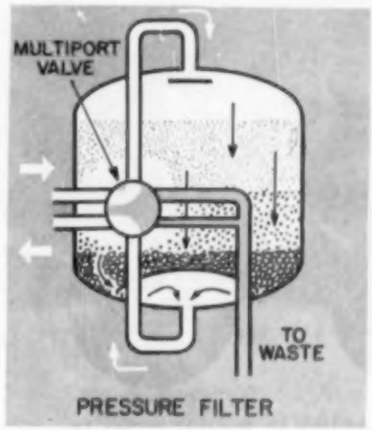
SAND FILTERS for removing dirt, precipitates, suspended solids

Sand filters simply "strain" the water as it flows downward through the filter bed. It is probably the oldest and most widely used method of water treatment.

Gravity filters. Practically all large public water-supply plants include a series of gravity filters made of concrete for permanence and low maintenance cost. Sizes run up to 400 or 500 sq. ft. for each filter.

Chief difference among concrete gravity filters is the method of water collection under the filter bed. The false bottom system provides uniform collection but requires about 2 ft. extra filter height and is highest in cost. Header-lateral collection systems of steel pipe are lowest in cost but do not provide perfectly uniform collection and can corrode. There are also patented systems such as Permutit's *Monocrete®* system which uses collapsible forms for casting lateral ducts in the concrete itself. *Monocrete* ducts are oversize for uniform collection and are corrosion-free since no metal is used. The cost is less than for false-bottom construction.

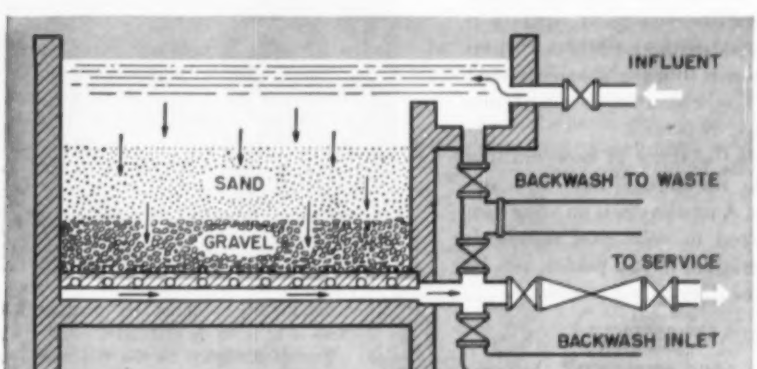
Steel-tank gravity filters cost less than concrete in small and medium sizes and are generally used in industrial plants. Wood-tank filters have low maintenance cost, but they are not practical for large sizes and not as attractive as painted metal. They are now used primarily where there is a metal shortage.



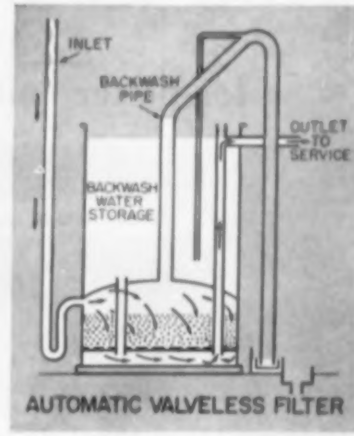
PRESSURE FILTER

Pressure filters deliver an effluent under pressure, usually under 100 psi, to eliminate repumping. Since no water depth is required over the bed to provide pressure, these filters are smaller and lower in cost than gravity filters of the same capacity.

Vertical pressure filters are available to 12 ft. diam. with approx. 113 sq. ft. of bed area. Horizontal pressure filters provide large filter-bed areas, up to 200 sq. ft., at lowest tank cost but may not maintain as uniform bed conditions as vertical type.



CONCRETE GRAVITY FILTER



AUTOMATIC VALVELESS FILTER

Automatic Valveless Filters (gravity type) are a new Permutit development. They greatly reduce filter cost because they use no valves or flow controllers. They provide completely automatic, foolproof self-operation yet actually cost less than conventional manually-operated gravity filters. Sizes up to 12' diam. available.

When the suspended matter removed by the filter bed causes the pressure loss to reach a predetermined figure, backwashing starts automatically. At end of backwash, flow reverses automatically, and the backwash storage compartment is then filled with a brief rinse plus filtered water. Filtered water then passes to service through a separate outlet.

FILTER MEDIA for removing oil, bad tastes, odors, etc.

Graded anthracite coal. Used in place of sand to minimize pick-up of silica following hot-process softening of boiler feedwater or for removal of oil from steam condensate.

Activated Carbon (Carbo-Dur®). Absorbs excess chlorine and dissolved elements caused by decayed vegetation or algae that affect taste and odor. Carbon filters or "purifiers" are backwashed to remove suspended matter picked up by the filter.

Calcium Carbonate (Neutralite) raises the pH of low-pH, corrosive water at the same time that it filters.

Manganese zeolite oxidizes and removes moderate amounts of iron and manganese, also hydrogen sulphide, chief cause of "rotten egg" odor and sulphur taste. It is regenerated with potassium permanganate.

For information on filters or other water-conditioning equipment, write: The Permutit Company, Dept. CEP-11, 50 West 44th Street, New York 36, N.Y. or Permutit Company of Canada, Ltd., Toronto 1, Ont.

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Noted and quoted

(*Continued from page* 6)

segment of that knowledge was obtained from us, some of it through inadvertence and some of it, as we all know, through the disloyalty of individuals privy to some details of our know-how. The danger to our national security through lack of proper security measures is as great or greater today than it has been at any time in the past, and the responsibility of the Commission to safeguard this security is not relaxed nor is it likely to be in the foreseeable future.

Since there is no clear line of demarcation between military and civilian technology in the atomic energy field, the Commission must be doubly sure that in releasing what appears to be strictly civilian information it is not at the same time compromising information of military value. This fact accounts for the frequent criticism of the so-called "secrecy policy" of the Commission, which criticism is, I believe, quite without justification.

The Commission desires to release and is releasing every bit of information about application of atomic energy which it can properly do consistent with its statutory mandate to protect and preserve our advantageous position with respect to military usage.

Peaceful Uses

The Atomic Energy Act of 1954 is the organic law from which the Commission derives its authority and in which are set forth its several responsibilities. One of these responsibilities is to "strengthen free competition in private enterprise." The Commission does not interpret these words as meaning that it should take a belligerent position in the public vs. private controversy, which has all the appearances of continuing indefinitely; and, in fact, the Commission does not take a position in this controversy, accusations to the contrary notwithstanding. We are dealing with and encouraging participation by both public and private groups in the development of nuclear power. If our assistance is in favor of one as against the other, it is in favor of public groups, such as cooperatives, not because we choose to take sides with them, but because their resources, financial and otherwise, are more limited than are the resources of private groups and, consequently, the measure of our assistance (in some cases at least) must be greater for them if it is to be effective.

The philosophy of the Commission in its endeavor to promote the peaceful uses of atomic energy is to make it a normal American business with

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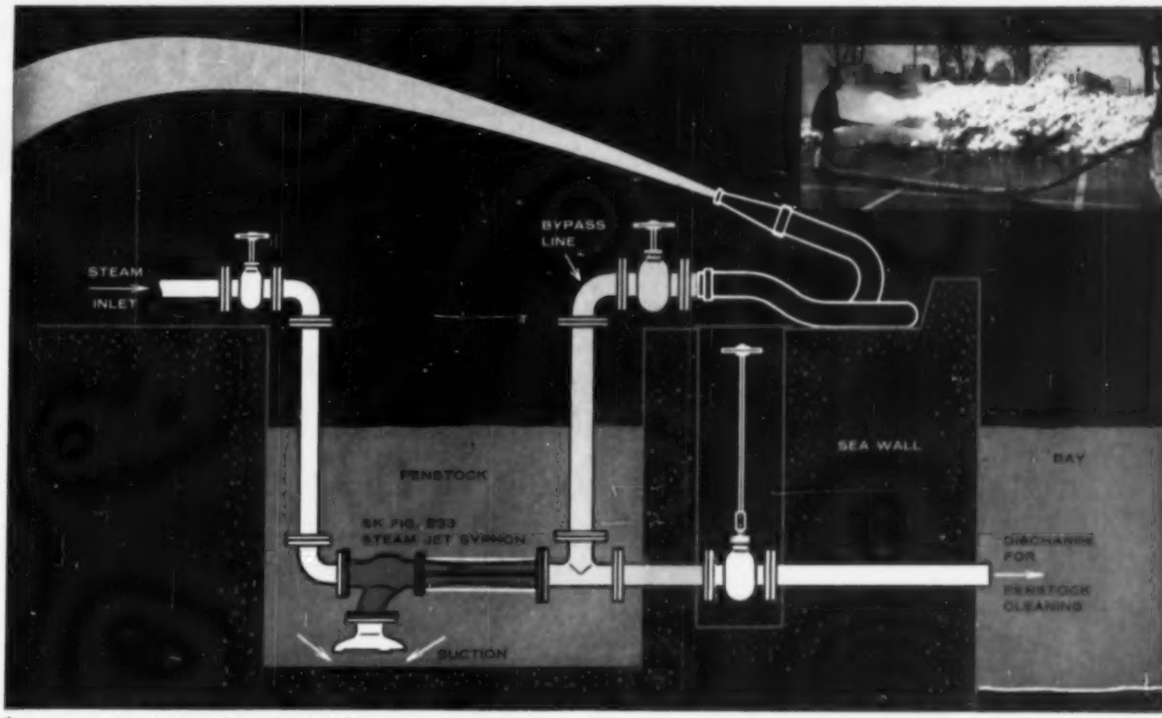

*STORY, DIAGRAM, AND PHOTO COURTESY OF GILLETTE SAFETY RAZOR CO., BOSTON, MASS.

THIS SK STEAM JET SYPHON

performs dual function at great saving

SK Steam Jet Syphon provides hot water for melting, removing snow. Syphons in large sizes, 4 in. (250 gpm) to 10 in. (3000 gpm) are widely used for emergency drainage. Small sizes, ½ in. (6 gpm) to 6 in. (600 gpm) are used for intermittent-but-frequent service.

Before installing the SK Steam Jet Syphon illustrated above, the manufacturer who devised this system* used contractors to clean accumulated silt from a plant-area penstock and used heavy, expensive machinery to clear snow from company parking lots.

Seeking a means to do both jobs themselves at less cost, company power engineers investigated, then installed, the SK 5 in. Steam Jet Syphon shown above. To clean the penstock, the bypass line valve is closed and the discharge-to-bay and steam valves are opened. Pressure steam, issuing from the syphon nozzle, entrains water and silt from the penstock and discharges, against a head, into the bay.

For clearing snow, as much as 500 ft. of 3 in. fire hose is attached to the bypass line. The bay line valve is closed and the bypass and steam valves are opened. The pressure steam entrains water from the penstock and discharges through the hose. The hot water from the hose, at 500 gpm, is used to melt and wash the snow into catch basins, see photo.

The syphon cost about $500.00. It now costs about $120.00 to clean the penstock (a substantial saving) and the cost of removing snow is about one-tenth of the previous cost.

Imaginatively applied, SK Jet Apparatus can do many jobs well at low cost. Learn more about Jet Apparatus by writing for Bulletin J-1 which describes SK's complete line and many applications.

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Noted and quoted

(*Continued from page* 8)

maximum industrial participation and minimum governmental participation as soon as possible. For example, as of now the Commission is the only customer for uranium ore produced in the United States. We offer a guaranteed market and established prices for approximately seven years to come, but we look forward to the day when there will be a free market for uranium ore, when private industry will take over, so to speak. It is certain that without governmental encouragement the mining of uranium ore, which today is an important factor in the economy of several of our Western States, would not and could not have been developed into anything like its existing proportions. The milling of uranium ore has been taken over almost completely by private industry, and we anticipate that the processing of the mill product through various succeeding stages now being done in government-owned and -operated plants will be taken over in due course by industry.

There are two important services which must be available if nuclear power plants are to be built and operated either at home or abroad. The first of these services is fabrication of fuel elements; the second is reprocessing them so that the unburnt fissionable material may be recovered. Already several American firms have entered the field of fuel element fabrication, and we look toward the time when increased volume and decreased costs due to technological advances will make the chemical reprocessing business attractive to industry. The Commission is eager to retire from this field just as soon as industry is ready to offer this necessary service at prices which are reasonable and will not discourage the advancement of nuclear power.

The Commission is anxious to have industry take up the making of radioactive isotopes and will retire from this field as soon as it can properly do so.

One evidence of Commission policy is found in this [Idaho Falls] meeting, the underlying purpose of which is to generate an interest on the part of American industry in building and operating test reactors. The Commission desires to withdraw from this activity as soon as industrial participation will allow it to do so.

International Aspects

Representatives of eighty-odd nations are now meeting in Vienna to establish the International Atomic Energy Agency, which is an affiliate of the United Nations designed to promote peaceful application of atomic energy on a worldwide basis. The Agency was first proposed by the President of the United States in December, 1953. Our country has taken a leading part

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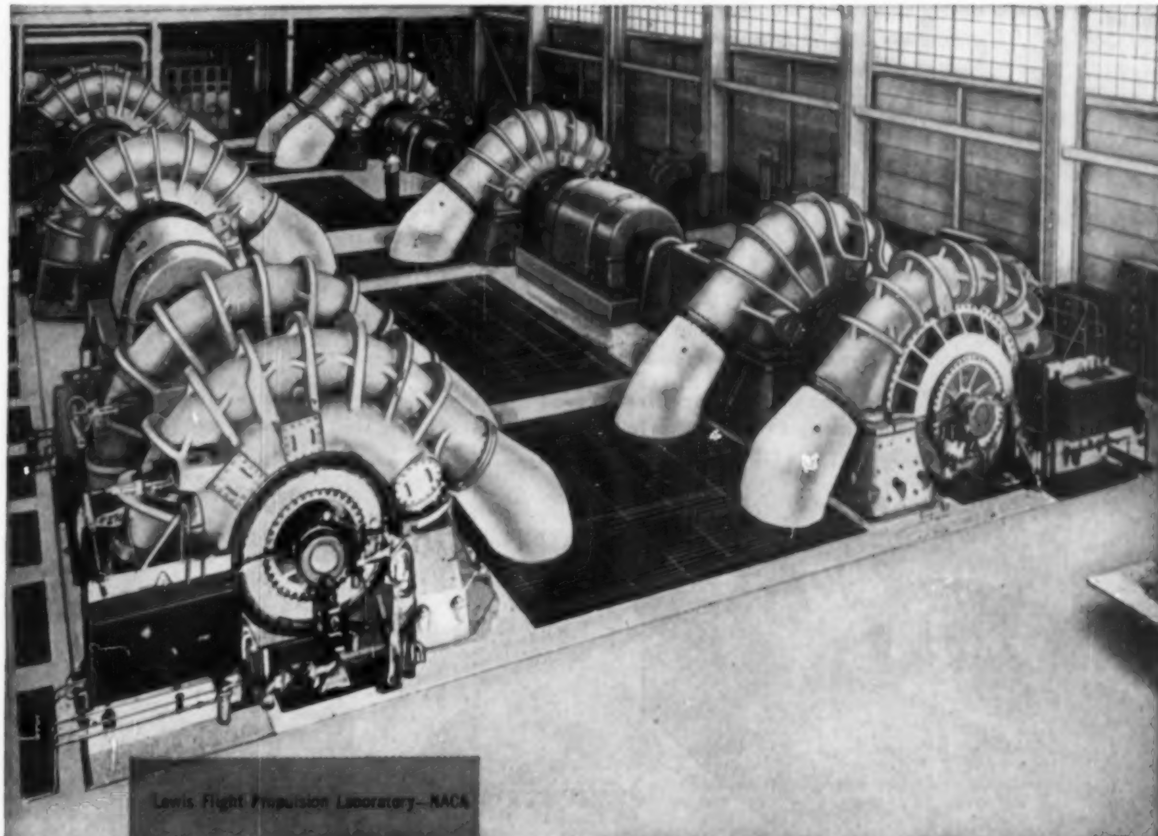

Lewis Flight Propulsion Laboratory—NACA

Noted and quoted

(Continued from page 12)

in its organization and will, I believe, continue to take a leading part in developing its operation. While there are several good reasons for our interest in and enthusiasm for the new International Agency, one of them certainly is the creation of opportunities for American industry to participate in the construction of power reactors and other types of reactors abroad.

Reference to the International Agency leads me to another misconception of Commission plans which is that we are allowing other countries to outstrip us in the atomic power race and that we are losing our position of preeminence in this field because we are not planning to build in the next few years as many kilowatts of nuclear power capacity as are programmed by Britain, Russia, and the countries of Western Europe.

This matter of where we stand relative to other countries in the development of nuclear power cannot be properly judged without a full realization of the great difference between power economics at home and abroad.

We in the United States are blessed with large resources of fossil fuels, to say nothing of a considerable amount of yet undeveloped hydroelectric potential. We have cheap electric power and will continue to have it in adequate supply from conventional fuel sources for at least another generation despite the fact that our power demand is about doubling every ten years. True, the day will come when we shall need power from all sources, including nuclear energy, but that day is not yet upon us as it is already in many other countries.

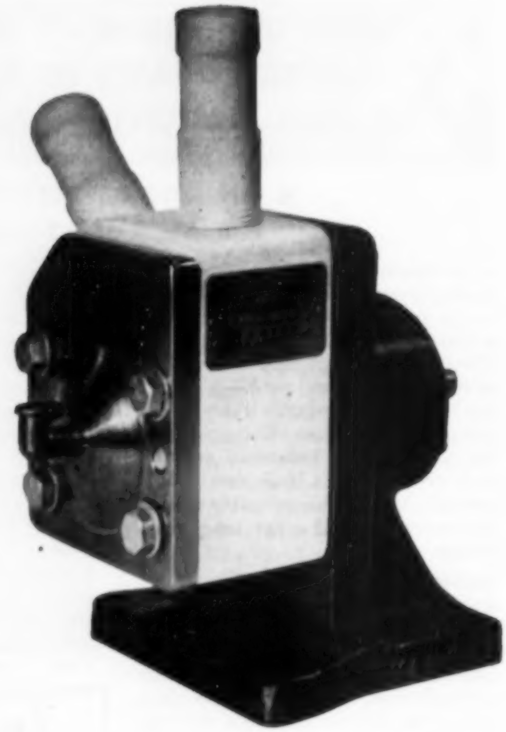
Britain, once a great exporter of coal, had to import last year nearly one fifth, (19 per cent to be exact) of the fuel needed to produce electricity. It is estimated that by 1975 Britain will have to import over 50 per cent of its fuel needs except for such relief as may come meanwhile from the exploitation of nuclear power. Imported fuels are costly and electric power derived from them is costly. Because of this fact, nuclear power in its present state of partial development is competitive or nearly so with conventional power abroad when that power is produced from imported fuels.

A situation similar to that of Britain exists in the Euratom countries of Western Europe, in Sweden, and in Japan, where today a substantial part of the demand for electric power can be met only by the importation of very high cost fuel.

Contrast the economic pressures in countries where electric power costs

(Continued on page 24)

NEW!



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No stuffing-box or shaft seals to leak, contaminate, or require maintenance!

Long-term maintenance-free operation even with aqua regia!

Now at last, here's a pump to solve for good your problems of pumping corrosive or abrasive liquids or slurries! HCl, caustics, $TiCl_4$, even fuming HNO_3 and fuming H_2SO_4 (oleum), all yield to the combination of Vanton's unique pump design with *Teflon and Kel-F*** *elastomer*, the outstanding new fluorocarbons that remain unaffected by even aqua regia!

The Vanton Pump design eliminates stuffing boxes, shaft seals, gaskets, and check valves. Previously available in many other plastics and synthetics, its appearance now in fluorocarbon materials enables it to provide prolonged maintenance-free pumping of almost any corrosive or abrasive substance in commercial production today.

All Vanton pumps are self-priming, high-vacuum, and available in a broad range of capacities from 1/3 to 40 g.p.m. In addition to Teflon, they are obtainable in 7 body and 10 flex-i-liner materials, including polyethylene, Buna N, hypalon, Kel-F, etc.

**TEFLON—Reg. trade-mark of Du Pont for its tetrafluoroethylene resin.*
***KEL-F—Reg. trade-mark of Minnesota Mining & Mfg. Co.*

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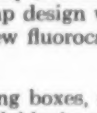

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UNITY OF THE PROFESSION

Joseph W. Barker
President of EJC and Chairman of the Board, Research Corporation

For many years there has been a growing desire among the members of the engineering profession for a greater degree of unity. In the early days engineering was primarily military. Its activities were centered on furthering the success of armies in their campaigns. In sieges, for example, this involved construction of fortifications for the defensive, and for the offense the construction of breastworks, sapping and mining operations, roads and camp sites, while for both sides the engineers built "engines of war" developing from crude catapults into artillery.

In time there came a natural division into military and civil engineering. Nearly every type of engineering activity pertaining to the development of peaceful civilization was encompassed in the term "Civil Engineering" and we had a high degree of "unity" in the profession. However, with the Industrial Revolution there began to be more and more specialization and the "splintering" grew apace.

Within each "splinter" there grew up professional groups dedicated to training the younger apprentices, to the interchange of professional information, and to the enhancement of the reputation of the splinter among the general population. These groups became formalized as "Institutions" in Great Britain, as "Societies" or "Institutes" in the U.S.A., each serving its particular branch. As technology became more and more complex, so did the internal structure of the profession and each of the societies became more and more specialized. We need no reminder of the vast number of engineering societies in this country today, each jealous of its individual reputation and of its prerogatives, each building a dedicated bureaucracy to serve its professional activities, each seeking to strengthen itself by enlisting as members all those engineers working principally in its particular field.

Let me interpolate here that this formation of separate societies was not inevitable—it just happened. Our forefathers in the profession might just as well have organized specialized divisions within one engineering society. In fact, within what we now call the "Founder Societies," each has been forced to organize a multiplicity of professional divisions in order to serve the complex needs of its membership and to minimize or retard the splintering process. If only our forefathers had taken that course of society development, we would not have had the unity problems of the past half century. This is, of course, just wishful thinking; they did splinter off and, unfortunately, we are still doing it.

But while we have been building this complex structure of a multiplicity of engineering societies, we have, in general, dedicated each such society to furthering the strictly professional and technical aspects of a particular facet of engineering technology. It can be said, as a generality, that engineers look to their particular engineering society for:

- **The collection and dissemination of technical information in their field,**
- **The establishment of the standards of practice of engineering in that field,**
- **The establishment of criteria which can be used by the public and by industry in evaluating the work of the individual engineer.**

Based on a talk delivered before ASCE October 14, 1957 in New York City.

Engineering Education

As engineering passed into the professional phase, the training for the would-be entrant passed from apprenticeship or cadetship under an established engineer into educational programs at the college level. Each branch of the profession became concerned with the maintenance of adequate quality in these educational programs, and the various separate societies formed educational committees. Soon these society committees began to exert pressures upon the engineering schools and often these pressures were widely different in the individual curricula. The societies also became concerned with the numbers and quality of those seeking admission to the engineering schools. And the societies became concerned with the early "in-service" training of the young engineers.

While never minimizing the importance of maintaining—even increasing—the interest of each professional society in the recruitment, education, training, and indoctrination of its future members, it became obvious that a unified approach to the solution of these relationships by all the societies was not only desirable but absolutely necessary. Leaders of the profession came together and, after much debate, much pulling and hauling, and many jealousies, they formed Engineers' Council for Professional Development. This cooperative endeavor has had outstanding success and is a most important element in the entire profession. However, had we had one engineering society from the earliest days, it would have been much simpler to achieve these desirable results.

Engineering Legislation

As technological progress and the products and activities of the engineering profession have important effects upon all citizens, our various state legislatures became increasingly concerned with these impacts, particularly upon the public health, safety, and welfare. These concerns developed into legislation designed to protect the public against "poor" engineering as it affected the public health, safety, and welfare, and took the form of required registration by the states of those holding themselves to be "professional engineers," somewhat as the public is protected against medical or legal malpractice. Since there was no single society of engineers within a state—as there are state bar associations—which could be entrusted with the administration of qualifying examinations, the legislatures, in general, established State Boards of Engineering Examiners with the power to administer examinations and to license as professional engineers those who so qualify. Either the legislative enactment or the administrative rulings of these various State Boards determine those who must register and the extent of the examination content which must be successfully achieved to gain registration. With wide variations in these requirements between the different states, there is lack of uniformity and also lack of reciprocity. Unlike doctors who practice principally in a restricted locality, engineers' activities are exceedingly widespread. For those whose fields require them to be "registered professional engineers," this can mean the necessity for registering in several or even in many states—a most confusing situation.

Also, engineering practice has largely developed into a group or team activity. The responsible engineering leader will be supported by many engineers—some equally responsible in cognate fields, others junior engineers. When such an engineering team undertakes projects which fall into the realms affecting public health, safety, and welfare, the problem of which team member is to be licensed and bear the public responsibility as a registered professional engineer raises many legal questions as yet unresolved.

Almost every engineering society encourages its members to become licensed and registered professional engineers, but only the National Society of Professional Engineers requires license by a state board as a necessity for membership. Only a fraction of the total number of engineers in this country are members of NSPE.

One Voice for Engineering

Since every engineering achievement has an impact upon the standard of living of our people (even though it may not directly affect the public health, safety, and welfare), there has grown up in this last half century an obvious need for some cooperative agency of all the engineering societies which could speak with one voice in promulgating engineering policy and philosophy to the general public. Many abortive attempts have been made in this direction and, finally, Engineers Joint Council resulted from the recommendations of a committee on unity, to whose deliberations all the interested engineering societies, including the National Society of Professional Engineers, were invited. Four separate and distinct plans for the development of the profession in a cooperative manner were considered. By the vote of the representatives of all the societies, with the exception of NSPE, the plan which received acceptance was that of Engineers Joint Council.

The Council plan was adopted because it permitted the maximum utilization of the existing engineering societies' structure, which, in turn, involved the interest of the individual members of those societies. The NSPE did not accept this concept because the fundamental development of its organization has been and is predicated upon the licensed member only and his interest in nontechnical phases of engineering.

The value of registration or licensing of engineers has been accepted by the Council since its inception as one criterion of the competence of the individual engineer. The present development of the profession dictates that the great majority of the members shall be college graduates. Upon graduation, these members are qualified and are eligible for the first step in obtaining a license. The usual time factor required to prove competence in the professional field is the same as that which pertains to membership in any of the present engineering societies which form EJC. Therefore, individuals who have qualified for membership in these societies are also qualified by education and experience for a license, whether they have one or not.

The practical and vital role of Engineers Joint Council, as the coordinating agency for the engineering societies, is in the promulgation of engineering policy and philosophy. EJC was created to do those things of common interest to engineers which could be done more effectively by joint action than by the societies' acting alone. Such joint interests relate primarily to the advancement of the art and science of engineering and its effects on that broad domain that we call the welfare of mankind.

The EJC member organizations differ in their concept of responsibility to their members. On the one extreme, a society has accepted the mandate of its membership to be responsible for all facets of engineering in that field, including technical and professional.

At the other extreme, there are societies who accept in practice the mandate that they are responsible for only the technology involved in that society's field of interest. It is because of this diversification that the Council is necessary and has been able to operate. The first society has been willing (at least in part) to abrogate to the Council a portion of its responsibility to its members for the unity of the profession. At the other extreme, the society interested only in the technical field has found the Council a medium of expression for its members in those fields in which the society itself is not prepared to take a positive stand.

Thus, there have grown up within the profession two joint councils, EJC and ECPD, and one separate and limited membership organization, NSPE. Between the two joint councils EJC and ECPD, there has been covered—to be sure with certain minor duplications—the major cooperative problems of the profession, with the sole exception of those pertaining to legislation affecting the profession, as such, and legislation on engineering projects affecting the general public. It can be said that EJC and ECPD have already minimized many overlapping activities and are presently doing even more in this direction, looking toward a to-be-desired amalgamation which would bring all the present cooperative activities of the engineering societies under one joint council.

UNITY

Cooperative Action

One activity desired by many engineers relates to legislation—both legislation affecting the profession as such, and legislation relating to engineering projects affecting the general public. Here, we enter an area of legal quicksand. Certainly, the public and its duly elected legislative representatives are entitled to know or to have presented at public hearings what expert professional opinion is upon any proposed legislation affected by engineering, or even for the necessity of legislation in some particular engineering area. As an example, EJC has just prepared and published a monumental study on water policy in which, where there are differences of engineering opinion, both the pro and the con are stated. This is a perfectly legitimate activity. But were EJC to draft legislation to carry this policy into effect and then to influence the passage of such legislation, this would jeopardize EJC and possibly even the engineering society members of EJC as to tax-exempt status.

Another example: EJC has just completed another large study on consulting practice. This is a cooperative general work to which each engineering society may add such individual appendices as will make the manual fit the peculiar conditions of that particular society. Yet, to propose legislation which would carry these principles into effect for public works would be an improper activity.

On the other hand, where legislation is being studied or drafted and the legislators ask EJC for comments or opinions, this supposedly does not jeopardize tax exemption. It is a fine hairline indeed and the quicksand can be dangerous. The National Society of Professional Engineers and its constituent state societies have very energetically entered into this field. But since their membership is limited to legally registered professional engineers and hence represents a minority of the total number of engineers in the country, they do not speak for the total profession. And since a large majority of their members are engaged in public works as employees of various public agencies, their opinions are not necessarily the same as those of the nonpublic engineers.

All of the foregoing indicates that while there is a widespread desire for unity among a vast majority of all engineers, there are many shoals to be watched out for; there are many vested interests to be overcome; there are jealousies and prejudices to be ironed out before we can have real unity. Yet, we are moving, slowly to be sure, in that direction and it will come eventually. The total membership of all the present engineering societies still does not constitute a majority of the total number of engineers in this country. So, it can be said that our present organizations are not really meeting the need for unity, nor are they completely serving the total profession.

I realize that hindsight is easier than foresight and that circumstances of times past dictated the manner in which our profession organized. To start over from the beginning is almost impossible or, more optimistically, would require much hard work over a long time. But, let me nevertheless sketch out a dream—one that has many analogues in our present societies' structures:

Suppose we had an "American Society of Engineers" to which every qualified engineer could belong. Its senior organization would then speak for the entire profession on such questions as education, legislation, engineering philosophy, engineering policy, etc. Under this senior organization would be, say, fifty departments, such as public works, extractive mining, mineral dressing, smelting, extractive drilling, refining, hydraulics, transportation, power, process machinery, communication, manufacturing processes, etc. And under each department a series of divisions; for instance, in transportation department there would be divisions on road, rail, water, air transportation, etc. Splintering to meet specialized needs could continue within the Society by subdivision, but the broad general problems and requirements caused by advancing technology would work upwards.

Isn't this dream but an extension to the entire profession of what our colleagues in the miners have just brought about? They have reorganized the old AIME into three departments: mining, metallurgy, and petroleum engineering — autonomous on technical questions, unified on professional questions. Each of the three major units or departments is further subdivided into specialties. Or isn't this but an extension to the entire profession of our own ASCE organization?

So, we actually have evolved in our special branches to meet the growing needs of specialization, but we have refused to apply upwards to the total profession what we have so readily adopted downwards.

Aren't we like the thirteen original colonies? We can and do join in a united front to fight an enemy, but we let our petty jealousies and prejudices write an "Articles of Confederation" in EJC and ECPD which keep us from effectively presenting a strong unified organization in a "Constitution of the United States." Just as the colonies struggled along for many years under the Articles of Confederation until finally they were forced to call a Constitutional Convention to get a truly federated unity organization, so we have muddled along with EJC, ECPD, NSPE until some day we, too, will call an Engineers' Convention and form a unity organization American Society of Engineers.

As consulting engineers, what would we say about an engineering project management as poorly effective as our multiplicity of separate engineering societies is? We would "pan hell out of it." Let's apply that same sound engineering analysis to our own problem and come up with some better answer than we have now or the "tripartite" confederation recently suggested.

Noted and quoted

(*Continued from page* 16)

twelve mills per kilowatt hour with the lack of such pressure in our own country, where the average cost of new power is about six mills, and it becomes quite apparent that the exploitation of nuclear power will and should proceed at a much faster pace abroad than it can justifiably do at home. We should congratulate ourselves that we have time in which to make further progress toward much more economical nuclear power before we have to use it extensively. Paradoxically, there is a realization abroad although not at home of how fortunate is our situation in the United States. In the eyes of our foreign friends, we are just exercising plain common sense in concentrating our efforts on research and orderly development, refraining from extreme exploitation until we can do so without doing real violence to sound economies.

The Commission is very much in favor of our helping our foreign friends in carrying out their ambitious programs for nuclear power. In exchange of information about operation as well as design improvement, we shall receive valuable aid toward our goal of nuclear power so economical that we can use it profitably in our own country.

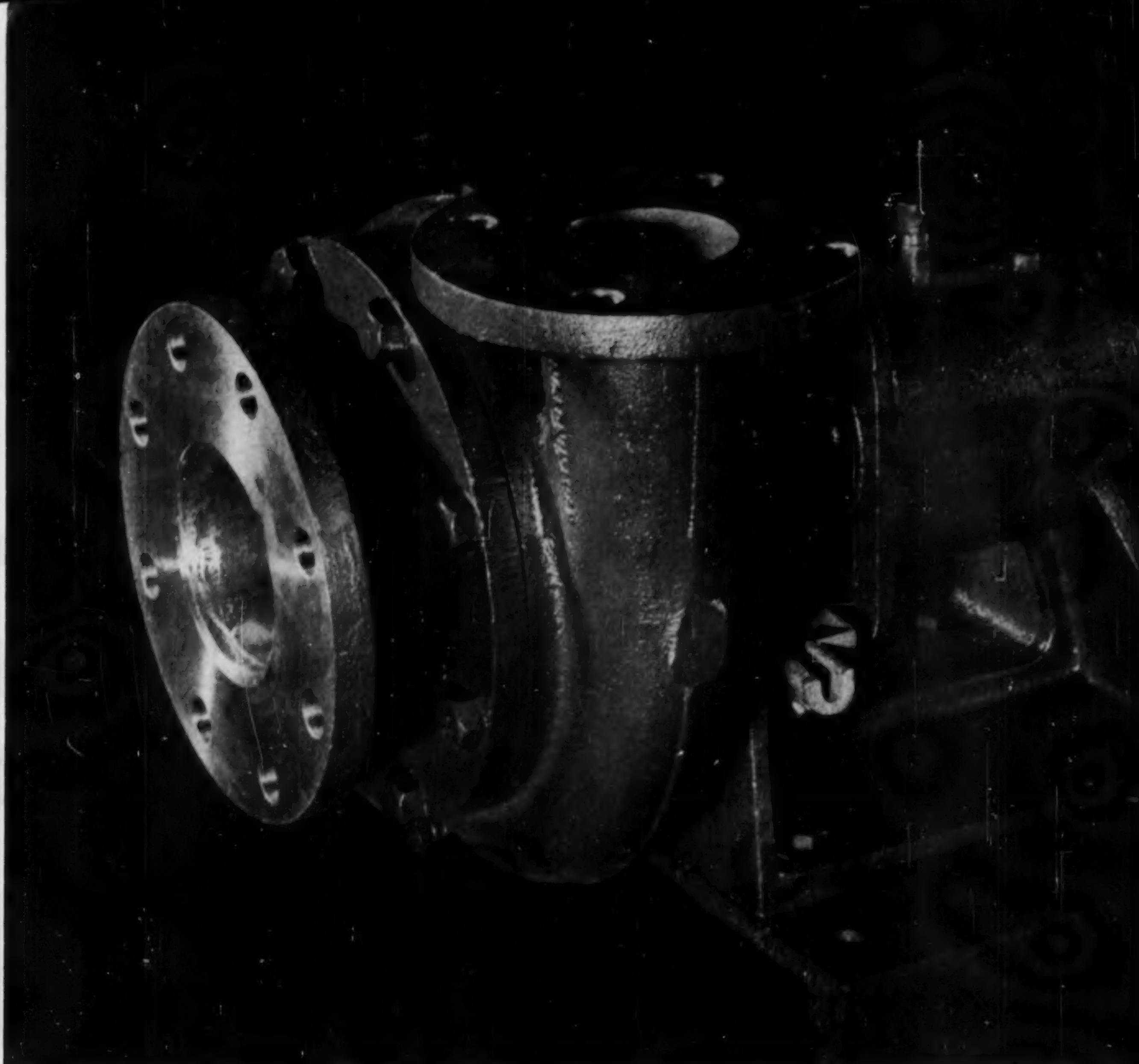
It seems to me that these examples are clear proof that the aim of the Commission is not to promote nationalization or socialization of American industry, but, in fact, is exactly the reverse thereof.

Nuclear Education

With respect to the accusation that the Commission is trying to control education or influence it improperly, it has been said that the Commission is attempting to limit its support of basic research in some manner and to concentrate it in government-owned national laboratories. While of necessity research work in the field of military application must be confined largely to our own laboratories, research in the fundamentals of nuclear science and in its peaceful uses is done to a great extent for the Commission not in its own laboratories, but on the campuses of universities and in the laboratories of private industry. At this time we have over seven hundred research contracts with universities, and I am sure that the scientists and technicians who are working on these contracts in university laboratories do not feel that they are subject to thought control by the Commission.

That many ambitious young scien-

(*Continued on page* 28)



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*A high nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U. S. Pat. Off.

Noted and quoted

(*Continued from page* 24)

tists should choose to work on Commission projects is but natural. Atomic energy is a new and exciting field with infinite possibilities. It is a specialization within the broader field of science which is and should be attractive to men of imagination.

In increasing numbers, universities and colleges are setting up, as a part of their regular curriculum, courses in nuclear science. To help them do so, the Commission is making grants for necessary equipment and is offering fellowships to induce students to elect these courses. It is the policy of the Commission to foster an independent spirit in the universities which are preparing to teach nuclear science. We are interested in encouraging them, but not in controlling or influencing them in any improper way.

I would think that within a decade—surely within a score of years—we shall see an evolution accomplished wherein industry will have completely taken over and assumed its normal position in the field of peaceful uses of atomic energy; wherein our institutions of higher education will have developed nuclear science as a regular part of their courses in general science; a situation wherein the Commission's activities, while continuing of necessity in the field of military application unless and until some plan of safeguarded disarmament has been agreed to by all of the nations of the world, nevertheless will be limited in the field of peaceful application to such things as cooperating with the states in establishing and enforcing uniform safety standards for the protection of people generally against those hazards which are inherent even in the peaceful uses of atomic energy and to research of a basic and fundamental nature, such as the discovery of how to control the thermonuclear process and how to make it economically feasible.

The Commission's policies are strictly in accord with the best American tradition—there is nothing "sinister" about them. But, it is true that in a complicated field like ours, where the public interest is so much at stake, where the requirements of military secrecy give an air of mystery to the entire effort, we must be mindful of the public view of our affairs and we must do whatever we can to see that there is a better understanding by people generally of our problems and of our policies. If we can bring about this better understanding, I am sure that we will thereby add something of real value to our other efforts toward the realization of the manifold benefits which will come from the peaceful uses of atomic energy.

Letters to the editor

Rockets and Chemical Engineering

A meeting took place recently which may have considerable significance to chemical engineers, particularly in helping to bring about a better understanding of some of the problems being solved—and yet to be solved—in the field of rocketry.

One hundred and sixty men sat down last month in a lecture room at Northwestern University's Technological Institute for a three-day discussion of transport properties in gases. Under the guidance and general chairmanship of Ali Bulent Cambel of Northwestern, the symposium was presented by Northwestern University and the American Rocket Society, and was sponsored by the Research Offices of the Army, Navy, Air Force, and an imposing list of industrial concerns.

Before the symposium had reached the luncheon break on the first day, the nature of the problem and a definite division of viewpoints among the participants was revealed. Values for transport properties (thermal conductivity, shear viscosity, specific heat, thermal emissivity, thermal diffusivity, mass diffusivity, and the dimensionless Prandtl number) were established as not only nonexistent at the high pressures and temperatures employed in the type of chemical process plant we call a rocket engine, but even theoretical visualization of them is baffling. Joseph O. Hirschfelder (University of Wisconsin), spokesman for the theoretical segment of the symposium, made the remark that for a simple case of two oxygen molecules there are eighty-one different possible energy potential exchanges. His remark that the energy interchange consideration, when complicated by additional factors of internal resonance forces at elevated temperatures, polyatomic and polar molecules, dissociation, ionization, and high pressures, vaguely resembles a "bucket of worms" served as a starting point for many floor discussions.

The symposium participants associated themselves with one of three principal viewpoints: (1) fundamental theory, (2) direct experimental determinations, and (3) mathematical extension of existing ambient values by sophisticated extrapolation.

In the opening paper, C. F. Curtiss (University of Wisconsin) summarized the theoretical side of the gas transport property task in a review of the Lennard-Jones potential for simple dilute gases, the Eucken correction to handle internal degrees of freedom, the Enskog theory extending the Lennard-Jones to denser gases, and some additional recent theory. Definitely not content with present theoretical tools, Dr. Curtiss said:

> The development of the high temperature field will ultimately have to include the theoretical calculation of transport coefficients, the existence of ions and free radicals being taken into account. To date no such calculations have been made and the authors know of no systematic attempts of experimentation in this area.

Quick to take Curtiss to task were C. V. Lin of Avco, D. R. Bartz of Cal. Tech., M. Rosenbluth of Convair, and C. W. Baulknight, who described extrapolation techniques they are using to provide engineering values for transport properties of high temperatures and pressures in the absence of complete theory.

Although not matching the demand for transport property values, the direct determination of these values is proceeding in many institutions. At Brown University J. Kestin and his co-workers are determining viscosity values for gases at high pressures and temperatures in a capillary viscometer.

Experimental work at MIT on thermal conductivity by Leslie H. Guildner, measurement of diffusion coefficients at Cal. Tech. by B. N. Sage, and the use of the molecular beam technique as a tool in gas transport property by I. Estermann were lucidly described.

However, neither theory nor the experimental work satisfied the intense requirements for good transport values soundly stated by representatives from the rocket, aerodynamic, nuclear, and chemical process industries. Upper temperature and pressure limits of 10,000° K. and 10,000 atmospheres were repeatedly stated as being real, present, and urgent.

The three-day session was forthright in presentation, but disappointing as a measurement of advancement. Post-symposium conclusions were that real values of even a few of the transport properties are nonexistent; that the theory is still limited; that experimental techniques will only produce with time and gifted operators; and that the need for values is mounting yearly.

Preprints of the nineteen papers may be obtained from the American Rocket Society, 500 Fifth Avenue, New York City. The bound proceedings will be available soon from Northwestern University.

*John F. Tormey**
Canoga Park, California

* Editor's Note: Mr. Tormey, a chemical engineer, is Chief, Research, at Rocketdyne.

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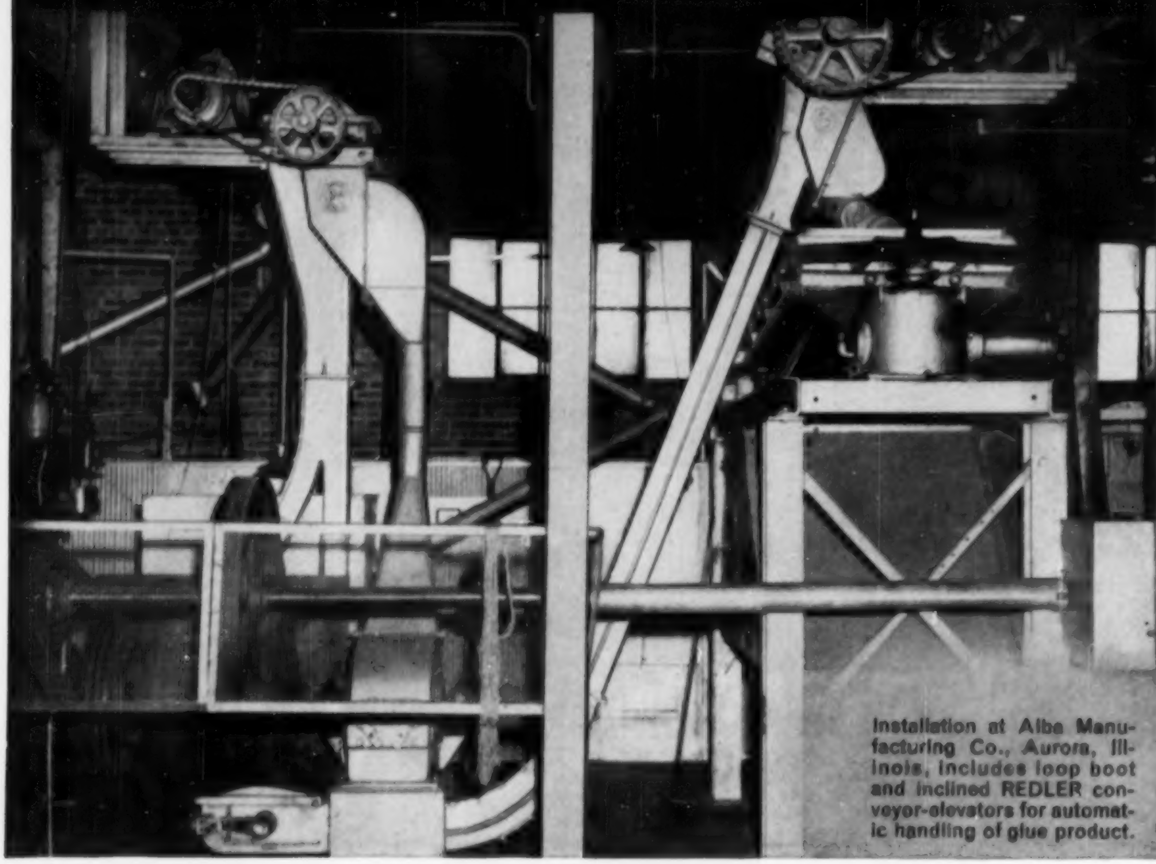

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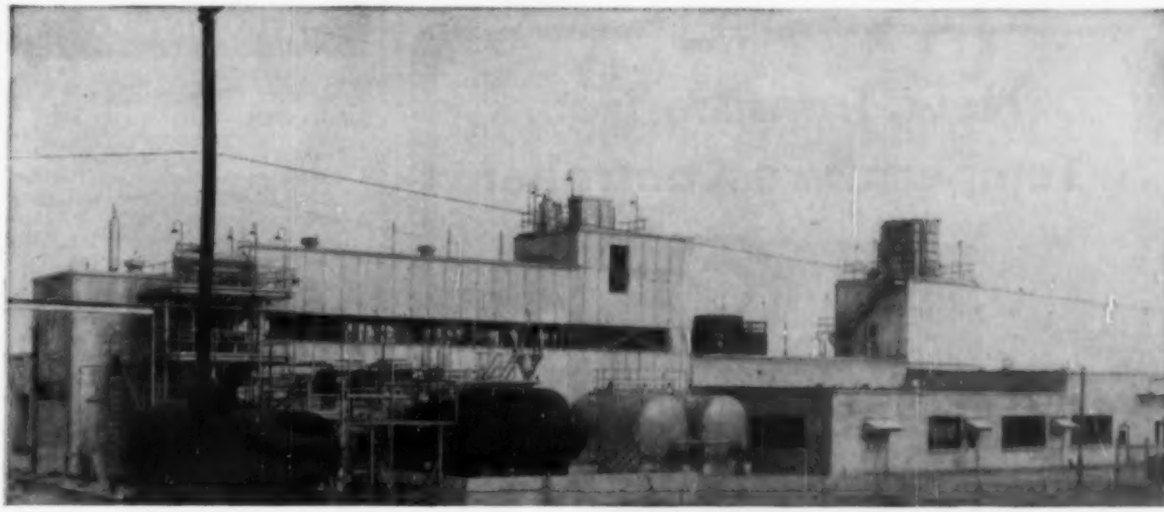

Polyvinyl chloride plant, designed and built for the Insular Chemical Corporation at Hicksville, New York, owned and operated jointly by Ross & Roberts Inc. and Rubber Corporation of America.

Heart of the process consists of reactors equipped with instrumentation for precise control of the process.

How Blaw-Knox builds an idea into a profitable resin plant

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Marginal notes

Review of Coolants and Moderators

Progress in Nuclear Energy, Series IV, *Technology and Engineering.* R. Hurst (A.E.R.E., Harwell) and S. McLain (Argonne National Laboratory). McGraw-Hill Book Company, Inc., New York, and Pergamon Press Ltd., London, 420 p. (1956), $12.00.

Reviewed by Albert L. Babb, Department of Chemical Engineering, University of Washington, Seattle, Washington.

This book is Vol. IV of a series of eight volumes entitled "Progress in Nuclear Energy." Vol. III, "Process Chemistry," and Vol. VII, "Economics and Administration," would also be of interest to chemical engineers in the nuclear energy field.

The aim of this series as stated by the editors is "first to emphasize technological rather than scientific aspects of coolants and moderators, second to select and commission papers broadly in the nature of reviews, and finally to preserve as far as possible some sort of geographical balance."

The first two chapters contain fairly detailed and comprehensive surveys of the production and properties of heavy water and reactor-grade graphite, respectively.

Chapter 5, titled *Engineering,* consists of sections which deal either directly or indirectly with heat-removal problems in nuclear reactor systems. Reactor coolants, pumps, and choice of pump system are covered. The section *Boiling Heat Transfer* is an excellent review of the subject. Other sections deal with the nuclear and thermal requirements of a primary coolant gas, experiments to improve heat transfer between aluminum and uranium surfaces in contact, and the thermomechanical behavior of an aluminum can as observed on an electrically heated model.

Chapter 6 is titled *Reactor Chemistry and Corrosion.* The chemistry of nuclear reactor systems and the extremely important field of corrosion in reactor components are covered. Phase diagrams for uranyl nitrate, fluoride, phosphate, chromate, and sulfate systems are given—a valuable compilation of available phase equilibrium data for systems of practical interest. Data on the resistance of metals to attack by both aqueous uranium and thorium slurries pumped at high temperatures are given.

Experimental data and photographs of corrosion test specimens should be

(*Continued on page* 40)

Marginal notes

(Continued from page 36)

extremely valuable to the practicing engineer.

From this reviewer's standpoint, the editors of this volume achieved their aim in making the volume essentially a technological review of coolants and moderators. In general, the individual papers are brief but well-written, adequately referenced, and the majority of them contain useful engineering data. A subject index is included at the end so its value as a reference book is enhanced. Consequently, this volume, as well as successive volumes in this series, should provide rather complete and up-to-date reviews of the technology and engineering associated with reactor systems.

Development of Industrial Dyes

Proceedings of the Perkin Centennial. Edited by Howard J. White, Jr., 468 p., $10.00. Available from George P. Paine, Lowell Technological Institute, Lowell, Mass.

Proceedings of the Perkin Centennial, New York, September, 1956, held to commemorate Perkin's discovery of aniline dyes. The sixty two papers presented at the Centennial are published in full, complete with charts, graphs, and illustrations.

Symposium on Industrial Water Problems

Industrial Water and Industrial Waste Water. Special Technical Publication No. 207, American Society for Testing Materials, Philadelphia, 52 p., $2.00.

Papers delivered at the Second Area National Meeting, Los Angeles, under auspices of the A. S. T. M. Committee on Industrial Water, covering many aspects of problems concerned with the source, use, and disposal of industrial water.

Solar Furnace Research Results

Study of the Utilization of a Solar Furnace for High Temperature Research on Solids, T. E. Tietz and N. K. Hiester, Stanford Research Institute for Air Force Office of Scientific Research, September, 1956, 10 p. Order PB 121930 from OTS, U.S. Dept. of Commerce, Washington 25, D.C., 50 cents.

A final report summarizing the major results and conclusions of five technical reports on theory, design and cost, and experimentation. The report permits evaluation of actual and proposed furnaces.

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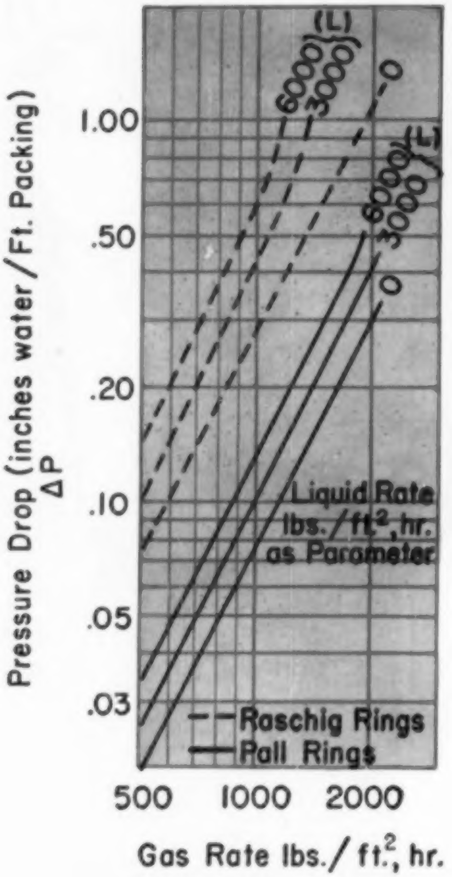

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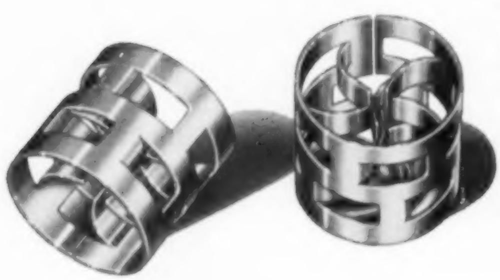
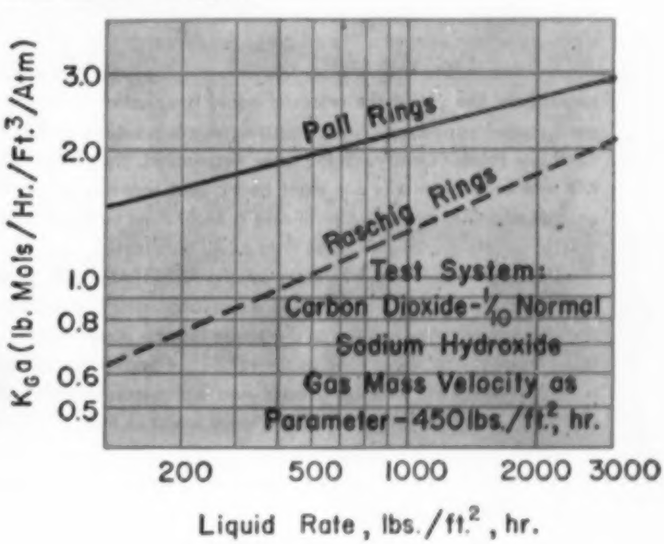
Take a careful look at the graphs. They show capacity data and pressure drop data taken from tests run not in an eight or twelve inch tower but in our new 30″ diameter experimental tower. The tests were made using 1½″ rings, packed to a depth of 8 feet.

This improvement in performance results purely from the characteristics of the Pall Ring. The Pall Ring differs from the conventional Raschig Ring in that sections of the ring wall are stamped and bent inward permitting better circulation of liquid and gas. Thus, more surface area is wetted resulting in greater active contact area between phases.

Metallic Pall Rings are made at present in 1″, 1½″ and 2″ sizes in carbon steel, stainless steel, aluminum and copper.





MASS TRANSFER COEFFICIENT vs. LIQUID RATE

For full information —

on Pall Rings and on other tower packings, write for a copy of Bulletin TP-54.

U. S. STONEWARE

AKRON 9, OHIO

101-F

News from

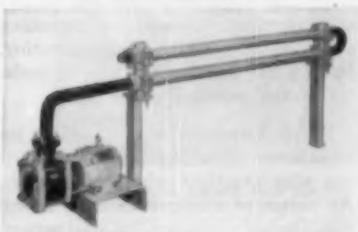
National Carbon Company

Division of Union Carbide Corporation · 30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. IN CANADA: Union Carbide Canada Limited, Toronto

PROCESS EQUIPMENT BRIEFS

Packaged "Karbate" Recirculating-Type Heat Transfer Systems for Plating Applications



Corrosion resistance, long life, low cost — these are some of the advantages of the "Karbate" recirculating-type heat transfer system. Designed for economical heating and cooling of plating solutions, the system features proven "Karbate" centrifugal pump and concentric tube heat exchangers.

Standard package units, available immediately, provide 4.1 to 35.2 square feet of heat transfer surface and circulating pump capacities of 20 to 100 gallons per minute.

For details, contact National Carbon Company, P. O. Box 6087, Cleveland, O.

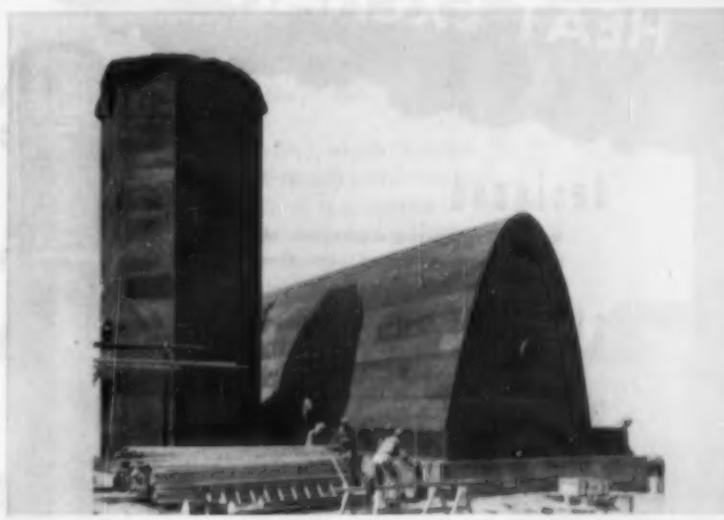
"Intalox" Saddle Packing Now Available in Carbon

Developed jointly by National Carbon Company and U. S. Stoneware Company, new carbon saddle packing has a wide range of chemical applications.

The new type saddles, sold under U. S. Stoneware's trademark "INTALOX", are recommended for hot alkalis, mixtures of hydrofluoric and sulfuric acids, hydrofluoric and phosphoric acids — applications where chemical resistant ceramics would be unsuitable. The new carbon saddles can withstand abrupt temperature changes without danger of spalling. Saddles assure maximum contact surface between liquid and gas or between liquid and liquid.

For details, contact U. S. Stoneware, 60 East 42nd Street, New York 17, N. Y.

VERSATILE CARBON AND GRAPHITE STRUCTURES CUT COSTS IN HIGH TEMPERATURE CORROSIVE PROCESSES



This installation has one of the largest capacity combustion chambers ever built. Made of graphite, the burner chamber (on right) and the carbon hydrator tower (on left) produce phosphoric acid from elemental phosphorus for the Shea Chemical Co. of Jeffersonville, Ind.

Corrosion resistance and structural stability at high temperatures make carbon and graphite invaluable in combustion chambers, reactor vessel linings, bubble cap trays and packing support structures. Virtually immune to thermal shock, and with little expansion under heat, carbon and graphite can be used in reducing atmospheres up to 3000°C. Furthermore, high thermal conductivity enables water-cooled graphite structures to withstand up to 2000°F under oxidizing conditions.

Easily machined to close tolerances, carbon and graphite can be worked even by hand tools. Depending on size and process requirements, the materials can be supplied for either monolithic or segmental structures. Segmental structures have been built with walls 20′ long x 15′ high, using blocks 7½″ thick, 28½″ wide and 72″ long.

After a carbon or graphite structure is completed, shoring is removed. Special high joint-strength cement with essential properties of carbon and graphite bonds the blocks or slabs.

NATIONAL
TRADE-MARK

UNION CARBIDE

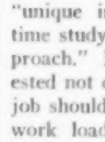
About our authors

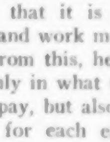
Joseph W. Barker, who writes on unity in the engineering profession, is an outstanding spokesman for both unity and the profession in general as president of Engineers Joint Council. An electrical engineer and president of Research Corporation (which is known to chemical engineers for the Cottrell electrostatic separator as well as its educational activities), Barker has had a most interesting history. Starting as an officer of Coast artillery (1916-1925), he then went into teaching, first at M.I.T., then at Lehigh, where he became head of the E. E. Dept. In 1930 he joined the faculty of Columbia University, becoming dean of the Faculty of Engineering. During the war he was special assistant to the secretary of the Navy.

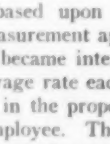
Ralph Landau, who advocates international licensing cooperation, is one who practices what he preaches. As executive vice-president of Scientific Design Company, he has personally developed and carried through a number of the international process development programs which he describes. An M.I.T. man, Landau spent several years on the engineering staff of M. W. Kellogg Co. From 1943-45 he was with Kellex, becoming head of the Chemicals Department there. Among his honors are the Kellex Key for his work in connection with the Manhattan District Project. An avid world traveller, Landau hops a plane frequently for "a few days in Europe."

Tom B. Haines is director of Industrial Engineering for Dow, and in this capacity has had much to do with establishing Dow's Job Evaluation Program. Haines describes this as "unique in that it is based upon a time study and work measurement approach." From this, he became interested not only in what wage rate each job should pay, but also in the proper work load for each employee. This information was of use in work supervision and in turn prompted the question of how many workers were *necessary* to perform any total of required operations. "The solution," he says, "involved reversing the normal time study procedure and combining work

(*Continued on page 52*)


Bloom


Brunsvold


Haines

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U.S.I. CHEMICAL NEWS

November ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1957

U.S.I. Joins Mallory And Sharon in Integrated Company to Produce Zr, Ti

U.S.I. will soon join in the management of Mallory-Sharon Titanium Corporation which will change its name to Mallory-Sharon Metals Corporation. The reorganized company will then produce zirconium and titanium metals and mill products, and other special light metals such as hafnium. Each of the following companies owns a one-third interest in the new enterprise: National Distillers and Chemical Corporation (U.S.I. Division), P. R. Mallory & Co., Inc. and Sharon Steel Corporation.

All assets of both the Mallory-Sharon Titanium Corporation and Reactive Metals, Inc., as well as USI-National Distillers' zirconium plant and forthcoming titanium plant will be combined in the newly formed corporation. With assets exceeding $55 million, the new company will be the largest fully integrated producer of special metals.

Presidents of the three owner companies have made this joint statement: "This consolidation of interests creates a completely integrated special metals company with technical 'know-how' and facilities for every step, from original chemical process to production and fabrication of finished products. The benefits from this strengthening of operations, plus the combination of current and future research activities, hold great promise for present production of titanium and zirconium and for other special metals as well."

Zirconium Metal Plant Starting Up

In 1956 U.S.I.-National Distillers was awarded a contract by the Atomic Energy Commission to supply one million pounds of zirconium metal annually for a five-year period. A plant was designed and built at Ashtabula, Ohio with a design capacity of 2 million pounds per year, and the plant is now in process of being started up. Hafnium sponge and oxide will also be produced as an adjunct to the zirconium operation.

A titanium sponge plant with a design capacity of ten million pounds per year is under construction at Ashtabula.

Both of these plants have been designed to utilize a new sodium-reduction process developed by U.S.I.-National Distillers. It is

MORE

Zirconium oxide kiln in chemical processing section of Mallory-Sharon Metals Zr plant.

Methionine Given After Exposure Reduces Damage From Radiation

Report Is First Evidence of Methionine's Effectiveness Against Tissue Breakdown When Given After Exposure to Radiation

New experimental evidence indicates that the sulfur amino acid, methionine, is even more effective in reducing tissue damage caused by radiation when administered *after* radiation exposure than it is when given *before* exposure.

Earlier reports have demonstrated methionine's ability to protect experimental animals from the effects of subsequent exposure to X-ray irradiation (U.S.I. CHEMICAL NEWS, Sept.-Oct., 1955). The present work, reported in a leading English scientific journal by Indian scientists working in Bombay, is believed to be the first to show methionine's post-irradiation effectiveness.

In the tests, deoxyribonucleic acid (DNA) levels in the liver, spleen and bone marrow were used as a measure of the extent of radiation damage. DNA is the substance in the nucleus of all cells believed to carry the mechanism of heredity. The researchers found that DNA levels in untreated animals were reduced by as much as 87% after exposure to radiation. DNA in methionine-treated animals was reduced to only about one-half of pre-exposure levels.

Methionine administered prior to irradiation afforded a considerable amount of protection, but was less effective than post-irradiation treatment. The radiolability of methionine—its tendency to be destroyed by ionizing radiations such as X-rays—is believed to account for this reduced effectiveness.

In evaluating the pre- and post-irradiation effectiveness of methionine, however, it should be noted that in the recent work methionine was given intraperitoneally. It has been reported (U.S.I. CHEMICAL NEWS, July, 1957) that radiation can cause a decrease in the ability of the body to absorb methionine that has been fed orally.

Methionine Aids Nucleic Acid Synthesis

The specific means by which methionine acts to prevent tissue damage from radiation is related to the nucleic acid synthesizing mechanism itself. Methionine is known to play a part in two chemical processes which are involved in the production of DNA — transmethylation and phosphorylation. (Methionine is a principal source of methyl groups for the animal organism and is a precursor of creatine, which is active in the phosphorylation process.) Thus, by aiding two of the essential routes by which nucleic acids are made, methionine keeps the synthesizing mechanism in order and exerts a therapeutic influence on radiation injury.

The considerable amount of research that has been done on methionine's effectiveness in minimizing radiation damage stems from methionine's well known ability to promote healing of wounds and burns. It is also a detoxifying agent through its action on the liver.

MORE

Brightness Is Controlled By pH in Sodium Peroxide Bleaching of Groundwood

A recently reported investigation into the fundamental chemistry of bleaching groundwood with sodium peroxide indicates that reaction rate and pulp brightness increase with pH. However above a certain pH, a colored compound is formed which tends to yellow the pulp. Therefore there is, in commercial practice, an upper pH limit for the production of pulp having maximum brightness.

Brightness Development in Sodium Peroxide Bleaching of Groundwood

pH	Time to reach max. brightness, min.	Effective Na peroxide consumption, g./l.	Maximum brightness, %
9.0	180 +	0.10	57.1
10.0	130	0.33	59.3
10.5	110	0.47	60.2
11.0	80	0.53	60.7
11.5	70	0.53	60.2
12.0	40	0.56	60.4
12.5	20	0.48	59.7

Sodium peroxide bleaching of groundwood has been used for some time by pulp makers. It produces a relatively large increase in brightness at low cost, without affecting pulp quality adversely or decreasing yield materially.

This study reveals that the rate of total peroxide consumption increases as pH rises from 9 to 12, due largely to the increased rate of the peroxide-groundwood reaction. The rate at which peroxide decomposes to form oxygen also goes up with pH, but this is minimized by materials in the groundwood and by adding stabilizers.

It was also learned that the rate and amount of brightness improvement increases with pH. Yellow color, mentioned previously, increases at the same time, the effect being more pronounced toward the end of the bleaching period. It causes reversion of brightness in some cases.

The most effective bleaching under the conditions used by the investigators was obtained at pH 11. Here the peroxide-groundwood reaction is fast enough, in relation to the decomposition reaction, to give appreciable bleaching in the first third of the bleaching period. On the other hand, the pH level is not high enough to produce excessive color shift and brightness reversion.

Sodium peroxide for groundwood bleaching is made from metallic sodium at U.S.I.'s plant in Ashtabula, Ohio.

November ★ **U.S.I. CHEMICAL NEWS** ★ 1957

CONTINUED Methionine

Methionine also is known to improve feathering in poultry and hair coat quality in fur bearing animals. As the only sulfur-containing essential amino acid, it is widely used in the manufactured feed industry as a protein supplement to promote growth and health in livestock and poultry.

The first commercial synthesis of methionine, which has led to its widespread use in medical and animal feed applications, was pioneered by U.S.I.

CONTINUED New Company

believed to be the lowest cost method developed to date for the production of these metals. Mallory-Sharon Metals will be granted an exclusive, royalty-free license in the U. S. for the production of titanium, zirconium and other metals by this process.

Sodium is supplied by the existing U.S.I.-National Distillers sodium operation three-quarters of a mile away. At Ashtabula, Mallory-Sharon Metals will also have facilities for melting zirconium metal into ingots.

Titanium sponge will be melted and both metals fabricated at the existing Mallory-Sharon plant at Niles, Ohio.

High Purity Silicon Being Made Via Sodium Reduction

High purity metallic silicon for electronics use in semi-conductor devices is now being produced by the sodium reduction of silicon tetrachloride. The product contains boron in the order of two parts per billion, and has resistivities up to 500 ohm-centimeters.

Several thousand pounds of the material have already been manufactured in one plant overseas, and indications are that this process is more economical than either hydrogen reduction of silicon tetrachloride or reduction of silicon monoxide.

New Cooling Towers Packed with Polyethylene Grids

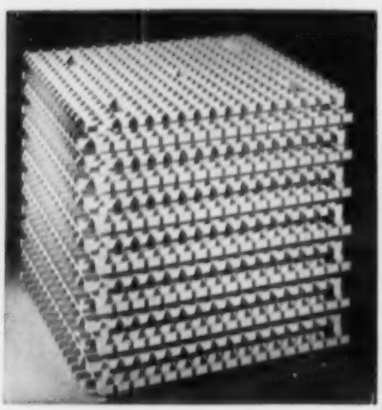

Photo shows typical stacking arrangement of polyethylene grids. (courtesy Fluor Products)

Polyethylene is now being injection molded into grid packings for water cooling towers. These grids are designed to provide the air-water contact surface usually provided by wooden bars or slats. They cool very efficiently, and eliminate maintenance problems due to their strength and corrosion resistance.

The grids are available in 2 sizes (3 ft. sq. and 2 ft. by 4 ft.). They are stacked vertically two inches apart in the cooling tower. This spacing arrangement allows for horizontal distribution of rising air and cascading water. It provides the same cooling efficiency as would the usual unspaced series of wooden slats while saving weight and material.

In addition to applications in new industrial and air conditioning cooling towers, these polyethylene grids can replace worn out portions of wooden packings in existing cooling towers. They have potential in gas scrubbers, trickling filters and other operations where efficient gas-liquid contact is desired.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U. S. I.

Polyethylene packaging materials are illustrated in a recent brochure. Bags, sheets, drum-liners and pressure-sensitive tapes are described, as well as water vaporproof, flexible and protective wraps made of barrier material. **No. 1291**

Buffer salts in disposable packets are now available. Each packet is carefully weighed, has been lot-analyzed for purity. Contents dissolved in a litter of water provide a ready-to-use buffer solution. **No. 1292**

Tape entry to computers is facilitated by a new machine with internal core storage, which gathers asynchronous digital information from external sources and combines them in any sequence with record numbers and manually inserted data. **No. 1293**

A new pamphlet on zirconia discusses the history, the chemical and physical properties, the composition, and the porosity of the chemical. Included is a refractory comparison chart. **No. 1294**

A calibrated dispenser delivers a specific volume of liquid from 1 cc. to 100 cc. rapidly and repeatedly. Measurement is automatic, said to be accurate to within 1%. Can be used for volatile, toxic, or alkaline liquids. **No. 1295**

Two monomeric ester-type plasticizers are said to be useful for safety glass, synthetic rubbers and lacquers, and as plasticizers for cellulose acetate butyrate, polystyrene, acrylic resins and ethyl cellulose. **No. 1296**

A pamphlet on fire research reports of the facilities, personnel and management of the principal agencies engaged in this work. It also describes tests of various materials and fire-protection systems. **No. 1297**

A polyethylene pump is now being made for use with inflatable boats and mattresses. Air is trapped inside the bag by folding the top together, and forced into the mattress through a valve by compressing the bag. **No. 1298**

Oleoresin mace, a new spice oleoresin, is described as a dark, reddish-brown, homogeneous liquid, and is said to be completely solvent-free. It contains from 50 to 60 cc. of volatile oil per 100 grams net. **No. 1299**

A new nickel stripper is reported to contain no cyanide, caustic or acid, and to be stable over long periods of time, even at high temperatures. Manufacturer claims it will not fume, pit or corrode. **No. 1300**

PRODUCTS OF U.S.I.

PHARMACEUTICAL PRODUCTS:

DL-Methionine
N-Acetyl-DL-Methionine
Riboflavin USP
Urethan USP
Intermediates

OTHER PRODUCTS:

Alcohols: Ethyl (pure and all denatured formulas), Normal Butyl, Amyl, Fusel Oil; Proprietary Denatured Alcohol Solvents SOLOX®, FILMEX®, ANSOL® M, ANSOL® PR.

PETROTHENE® Polyethylene Resins.

Esters, Ethers and Ketones: Normal Butyl Acetate, Dibutyl Phthalate, Diethyl Carbonate, Diethyl Oxalate, Ethyl Acetate, Ethyl Ether, Acetone, Diatol®.

Intermediates and Fine Chemicals: Acetoacetarylides, Dimethyl Hydrazine, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Chloride, Ethyl Sodium Oxalacetate, U.S.I. ISOSEBACIC® Acid, Methyl Hydrazine, Sodium Ethylate Solution, Triethyl Aluminum, Trimethyl Aluminum, Urethan USP (Ethyl Carbamate).

Animal Feed Products: Calcium Pantothenate, Choline Chloride Products, MOREA® Premix, Special Liquid Curbay®, DL-Methionine, Niacin USP, Riboflavin Concentrates, Vitamin B_{12} and Antibiotic Feed Supplements, Vacatone® 40, Vitamin D_3 and K_3 Products, Antioxidant (BHT) Products, Special Mixes, U.S.I. Permadry Products (Sealed-In Vitamin A).

Inorganic Chemicals: Ammonia, Caustic Soda, Chlorine, Metallic Sodium, Sodium Peroxide, Sulfuric Acid.

Metals: Titanium Sponge, Zirconium Sponge, Zirconium Platelets, Hafnium Oxide, Hafnium Sponge.

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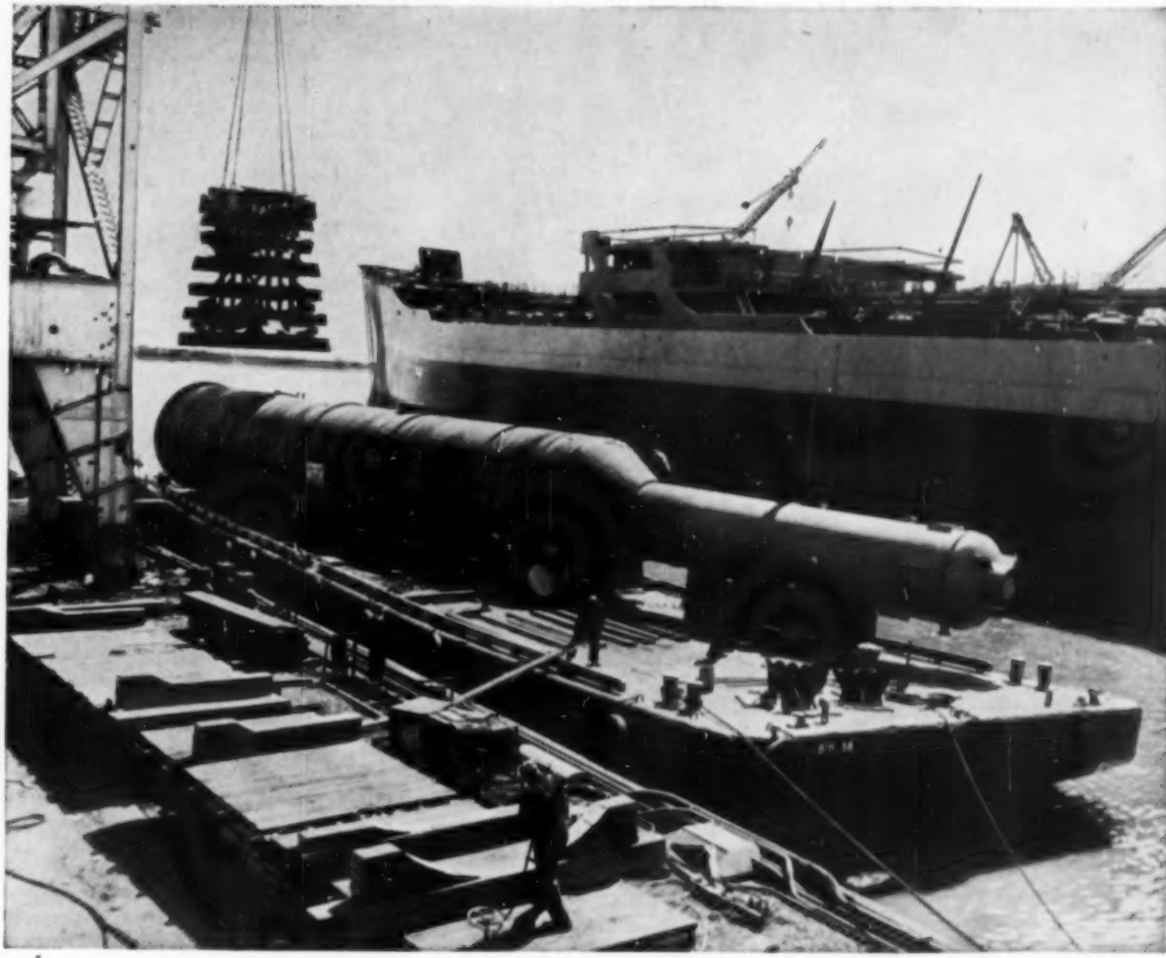

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The variety of work which Sun Ship's integrated shops produce for use by industries on land and sea brings a matching variety of shipping problems.

Our facilities for tidewater shipment are used to economical advantage on many of the massive structures that go into the making of the nation's petroleum and chemical industries. The barge shipment of tower and shed row baffles, shown above, is a good example.

And of course—when shipment by land is necessary—Sun Ship rigging and routing find the ways and means to handle such items as large-diameter columns by rail and truck.

It's all a part of the versatility which forty years' experience has made part of "standard procedure" in service of its customers.

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SHIPBUILDING & DRY DOCK COMPANY

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About our authors

(Continued from page 44)

elements to build proposed jobs." Correct labor requirements along with proper wage rates and balanced work load requirements produce the complete picture necessary to deal effectively with organized labor and to operate efficiently.

Charles F. Gerlach, who writes on the relationship between soda ash and the chlor-alkali industry, has been associated with Wyandotte Chemicals since 1951. As sales manager of inorganic chemicals, he handles Wyandotte's broad line including (besides caustic) soda ash, chlorine, calcium carbonate, hydrogen, lime, bicarbonate of soda, and calcium chloride. Before joining Wyandotte, he was with Michigan Chemical Corp., where he attained the rank of vice president and general sales manager.

Ralph Bloom (Hydrogen Peroxide) is technical coordinator for government activities on the management staff of Becco Chemical Division of Food Machinery. He joined the predecessor firm (Buffalo Electrochemical) in 1947 to specialize in R & D with regard to applications and handling of concentrated hydrogen peroxide. Before this he was a Lieutenant Commander at the U. S. Naval Engineering Experiment Station at Annapolis. Among his more interesting projects was the testing of a German submarine propulsion system using concentrated hydrogen peroxide. **Norris J. Brunsvold,** co-author, is supervisor in Becco's Chemical Department on applications and handling of concentrated peroxide and other government-sponsored research activities. He came to Becco through the Westvaco Div. route, starting in research, then becoming chief chemist at the new Green River, Wyoming soda ash plant.

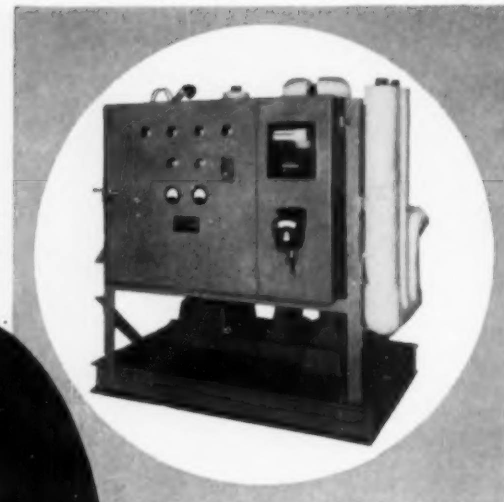
Helmut W. Schulz is associate director of development of Union Carbide Chemicals at South Charleston. He is responsible for the planning and review of the technical program of the Development Department, and supervises the Operations Analysis Section—about which he writes in this issue. Previous to this staff position, he had line responsibility for a variety of R

(Continued on page 56)

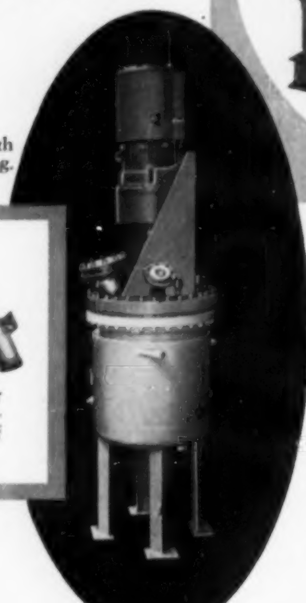
Landau Gerlach Schulz

PROCESS SYSTEMS

. . . Whitlock Specialties



Transfer Oil Heating System, complete unit ready to install. Temperature controls maintain the oil supply temperature within ± 2° F. Available in Standard, or Group 1 Class D Explosion-proof Constructions.



Jacketed Kettle complete with agitator for grease processing.

Secondary Gas Precooler used with reactor in chromium ore plant. Two corrugated expansion joints accommodate expansion of parts due to elevated temperatures.

Large Convertor with auxiliary heat exchangers comprises a complete operating unit.

Whitlock's long experience in designing and building heat transfer equipment for the processing industries assures you the most satisfactory "in-service" equipment. We fabricate not only the standard sizes and types of heat exchangers but engineer and manufacture packaged systems, with all operating components, to perform specific tasks.

Send us your flow sheets specifying fluids, temperatures, and pressures. Our engineers will design the equipment you need. We'll supply all components, if you wish, including exchangers, tanks, pressure vessels, condensers, columns, reboilers, coils and piping. We save you the cost and trouble of obtaining the various components from many different sources and our extensive stocks of materials permit prompt shipment of your equipment. The savings are considerable, of course . . . in time and money . . . when you concentrate responsibility for your engineered equipment in a single competent producer. Write us today for further information and recommendations.

THE WHITLOCK MANUFACTURING COMPANY
97 South Street, West Hartford 10, Connecticut
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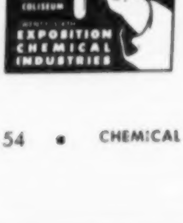
Primary Aftercooler removes heat generated in compressing ethylene gas.



Be sure to visit Booth 1181 at the Chem Show

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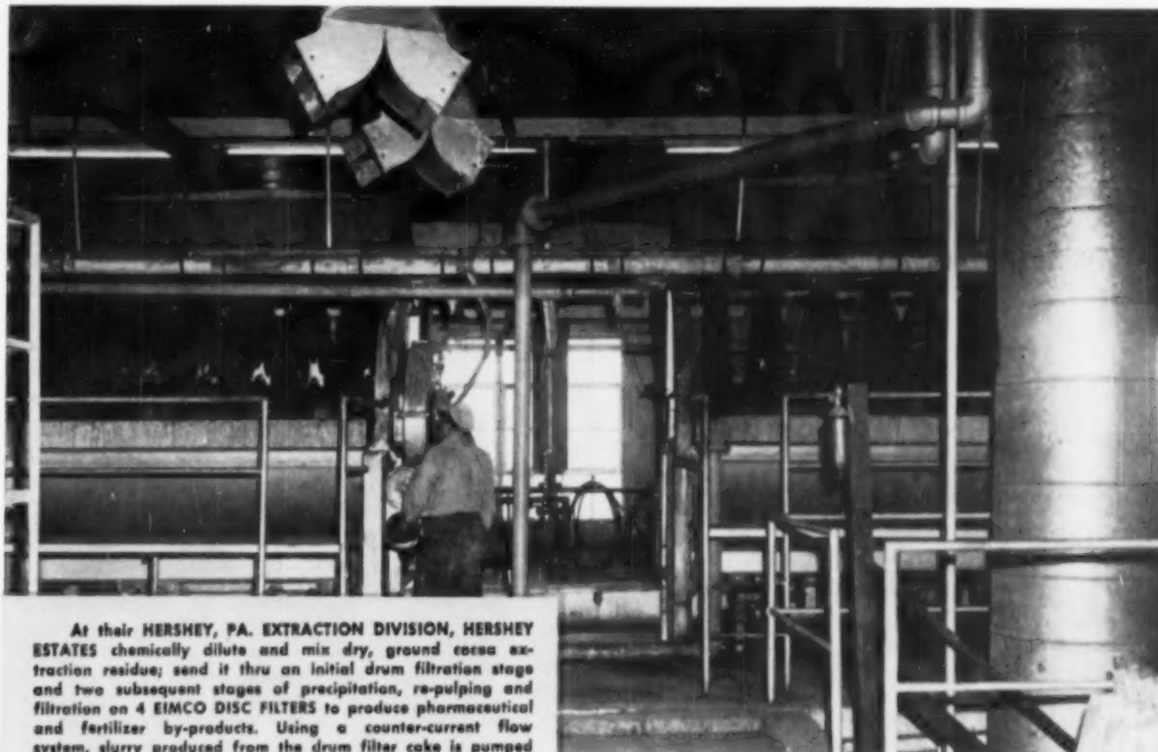
Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers



At their HERSHEY, PA. EXTRACTION DIVISION, HERSHEY ESTATES chemically dilute and mix dry, ground cocoa extraction residue; send it thru an initial drum filtration stage and two subsequent stages of precipitation, re-pulping and filtration on 4 EIMCO DISC FILTERS to produce pharmaceutical and fertilizer by-products. Using a counter-current flow system, slurry produced from the drum filter cake is pumped to Eimco Filter Station No. 1 (large photo). Final Precipitate is gravity fed to Eimco Filter Station No. 2 (directly below), and the end-product is transported to storage on a continuous belt conveyor. Bottom photo shows closeup of Eimco Disc cake formation.

EIMCO FILTERS - SERVICE WIN HERSHEY´S CONFIDENCE

HERSHEY, PA. - Client confidence in Eimco filter equipment and service over a period of 15 years, is expressed by **Mr. H. B. Brewer,** operating manager of the **Extraction Division, Hershey Estates.**

In 1941 . . it became feasible to add a two stage precipitation, re-pulping and disc filtration process to the flowsheet producing by-products from dry, ground cocoa extraction residue.

Mr. Brewer describes operation of two disc filter stations subsequently designed and installed by Eimco, "highly satisfactory. Over a 15 year period of around the clock operation, they have given us a dependable, efficient operation that has increased production and improved product quality."

This performance is a tribute to the durability and high mechanical operating efficiency of **Eimco** equipment and **Hershey's** intelligent maintenance program on a "planned" rather than "emergency" basis. From time to time, **Eimco** engineers and **Hershey** technologists have worked hand in hand to develop improvements to bring plant capacity to its present 90 tons of solids-per-day production.

The skills and experience that have won such lasting client confidence are at your disposal. Write today . . there's an Eimco Branch and Engineer in your vicinity.

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B-288

About our authors

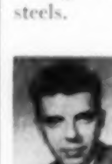
(Continued from page 52)

& D projects, including the direct hydration of ethylene and propylene, several processes based on the oxo reaction, the high-temperature condensation of aldehydes, synthesis of acrolein and a family of three-carbon chemicals, and the preparation of condensation fibers.

Bernard G. Ryle (Gamma Control of Extraction Column) has been with National Lead Company of Ohio's Feed Materials Production Center at Fernald for about five years. Throughout this time, he has been closely associated with the R & D phases of solvent extraction of uranium ore and ore concentrates. The most unique feature of the process in general was the handling of slurries of the concentrates rather than the preclarified solutions in perforated plate, pulsed columns (*CEP* has published on this, will soon continue with more details—*Editor*). Mr. Ryle feels his main contributions to the general area lie in overcoming the inherent difficulties arising from the three-phase system (which includes the presence of solid phase in slurry) in large scale equipment as opposed to the more common two-phase system.

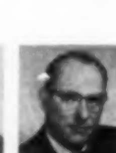
Mars G. Fontana is so well known in the field of corrosion that he needs no introduction to *CEP* readers. Mars is professor and chairman of the Department of Metallurgical Engineering at the Ohio State University. He is the author of a just-published book, "Corrosion: A Compilation," was president (1952) of the National Association of Corrosion Engineers. In 1956, he was the recipient of the N.A.C.E.'s Speeler Award for corrosion engineering.

Another author active in the N.A.C.E. is **J. J. Halbig**, who joined Armco Steel Corporation in 1940. His work now consists largely of investigating and reporting on a wide variety of customers' corrosion problems, conducting and reporting on laboratory and atmospheric corrosion tests, advising on the selection of construction materials in many types of corrosive service, and counseling on proper cleaning procedures for corrosion-resisting steels—particularly stainless steels.



Ryle

Fontana



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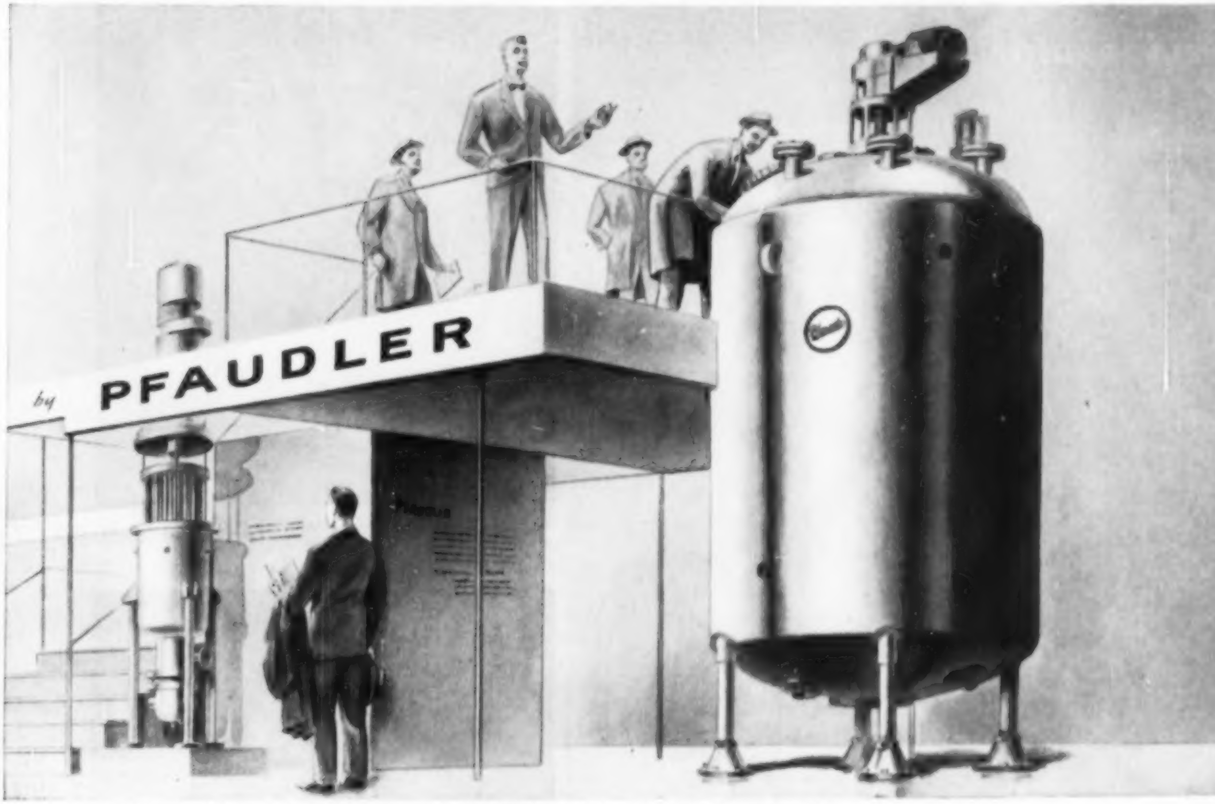

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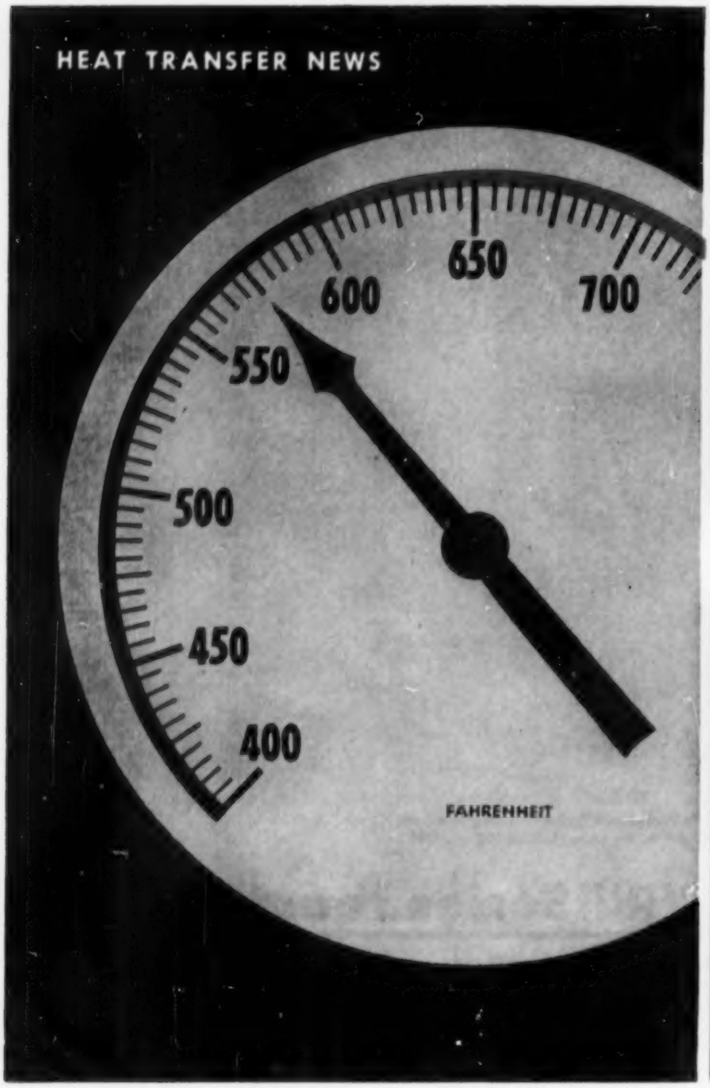

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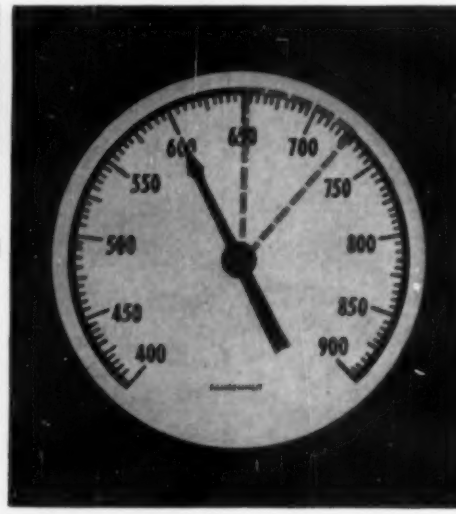

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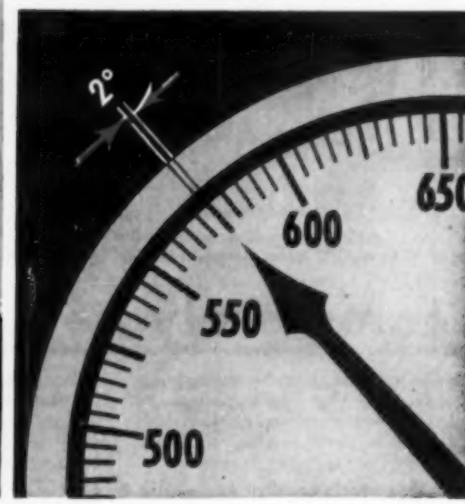

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CEP trends / SPUTNIK UP MARKET DOWN

The most striking recent news was the Russian announcement of the successful launching of their Earth satellite "Sputnik," thus arousing fears that the United States has lost its lead in this critical scientific area. While little is known about the satellite definitely, it seems unlikely that it is carrying such instruments as cameras for mapping, for example.

The real point, of course, is that Russia is able to make rockets with sufficient thrust to get such an object out to its orbit. This means in turn that the Soviets almost certainly have a successful intercontinental ballistic missile (ICBM). But again, whether or not they have one that would be accurate in hitting its target is not known. Nonetheless, the implications of the launching and the probable effects upon our internal economy and our foreign policy may be profound. A storm of criticism of our apparently lagging military efforts has been aroused.

Curtailed Defense Spending

This blow to our prestige comes hot on the heels of the curtailment of spending for airplanes. The Pentagon notified the airplane companies of a strict schedule of cash payments for the balance of the year which in effect was a reduction in progress payments of 20 to 30 per cent. The reason for the cut was to keep spending within the budget, but its result is to put airplane firms in serious financial straits at a time when money is scarce and rates are high.

Among immediate effects has been a heavy layoff by Republic Aviation on Long Island, which let out 2,500 employees on top of another 4,000 laid off previously. Subsequently, a Boeing Airplane Co. official said that the government action may force a major production slowdown by his company, which makes missiles as well as planes. Chance Vought also plans cutbacks. All of this is at a time when it would appear that the United States should be stepping up its expenditures and its efforts in the airplane and missile field.

Since our missile program and development in new high energy fuels has been pretty well under wraps of military secrecy, there has been much confusion as to where the nation really stands in its program and whether the Russians are really in the lead or not.

Several possible—even probable—developments in our defense policies should come as a result of the sensational news of the satellite, which has obviously jarred the public, the politicians, and the military. One may be a more liberal spending on defense which in turn might compel the raising of government debt limits, throwing budgets out the window and abandoning hope of tax cuts: a tax cut next year now seems quite unlikely. Another result is likely to be an examination of just where we stand in our missile program, with top scientists called in to give their ideas and their criticisms of the military.

While nothing is likely to happen in a hurry, one can see in the offing a reversal of the tight money policy of the Federal Reserve and a return to the inflationary spiral that has been going on for the past several years. If the nation is going to step up its defense spending materially, spurred by Russian threats in the Middle East, it is hard to see how we can have an economy program at the same time. When Congress returns it seems almost certain that a move will be made to lift the national debt ceiling. When and if this occurs, effects should again be seen in rising commodity prices and another round of wage advances, although with the present highly uncertain business picture this situation does not seem to be around the corner.

In the foreign field, the Sputnik will also affect our policies. Whatever its military significance, its effects as a propaganda weapon have obviously been tremendous. The Soviet is already showing renewed belligerence, both in talking and in extended efforts to push Syria and Turkey into a squabble. We shall probably have to live for some time in an atmosphere of recurring crises.

Unhappy Market Picture

Meanwhile, although the need for more defense spending and an unbalanced budget augurs more inflation in a year or more, the current business picture does not look happy.

The stock market, believed to be a barometer of business in many circles, continued its downward course. The slump both in freight car loadings and truck loadings continued to deepen. September freight car loadings dropped 9.6 per cent from September 1956 against a drop of only 2 per cent in August. As a result, railroads have been paring their payrolls.

Another unfavorable indication was a drop of $4 a ton in steel scrap prices in October, bringing scrap down to the lowest levels in two years. The automobile industry, meanwhile, still appears to be going fairly strong although production of cars has been running below last year.

The chemical industry continues to have sales at record levels and executives, while not downhearted, are less certain about the balance of the year than they were. Profit margins in most cases continue to be squeezed. And there are continued reports of under the table price cutting in some leading plastics.

opinion and comment

VISIT TO THE MISSILE MEN

In these days of acute awareness of missiles, consideration should be given to the contribution the profession can make to, and the effect on the profession by, missile technology. This is a brief report on *CEP*'s recent visit to major installations to initiate such consideration.

Missile technology, like nuclear technology, is a field needing much from many disciplines. But does it need much from the chemical engineer? "Yes," replies one chemical engineer who has been in the field since the end of the war. "A ballistic missile engine is really just a portable chemical plant with an electronic brain, in a cigar-shaped airframe." Some of the big missile engines operating on hydrocarbon fuel with liquid oxygen "are essentially water gas generators," he continued, "operating at tons per minute and B.t.u.'s per square inch per second, instead of the rates more conventional to the chemical engineer."

Are chemical engineers making much headway in the missile development field? Again the answer is yes. Chemical engineers are in a number of key positions, both administrative and in direct conduct of development work. One firm, obviously one of the largest, employs about 200 chemical engineers, has a chemical engineer as chief engineer (over a total professional staff of 2,000). Another organization follows a different policy by seemingly placing in its key positions only technologists who have acquired a most thorough specialized training in the operational end-products.

On the other hand, groups emphasizing the individual disciplines also seem successful in their approach, which perhaps has more aspects to it regarding *why* things work—an aspect that has not always been of prime consideration in the past, considering that the total life span of this major field is still little more than a decade. "We are just beginning to feel we understand the mechanism of burning of the fuel-oxidizer components dispersed in the "charge" of a composite solid propellant," said one leader in fundamental studies.

If one is willing to grant, as many leaders in the field are, that the chemical engineer has an important place in missile technology, then a natural question is: are any special qualifications or training required for entry to the field? To this question, the answers given *CEP* totalled up to one conclusion: The missile groups are, in general, seeking chemical engineers with the best training available in fundamentals, are discounting training in manufacturing processes. But seeking is not the same as getting, and so these groups are also seeking men with aptitudes for advanced fundamentals, then literally sending them to school to get additional training in math, physics, and, in particular, statistics. This is in addition to specialized training in missile technology.

As to the effect missile development may have on the profession, "It will have a pronounced effect on opening up new limits and shortening the control-time base of the chemical process," said another chemical engineer. "Remember this," he continued, "we're pushing everything to the absolute limit—temperatures, materials, reliability. Propellants are getting nearer and nearer to being explosives. At the same time we're cutting safety factors to the bone . . ."

If there is one thing the chemical engineer in this courageous new professional venture wants more than anything else, it is positive indication that his profession is interested in what he's doing. "We don't like to feel like we're Buck Rogers' associates," said one young fellow, looking across the scenic, but empty, desert.

J.B.M.

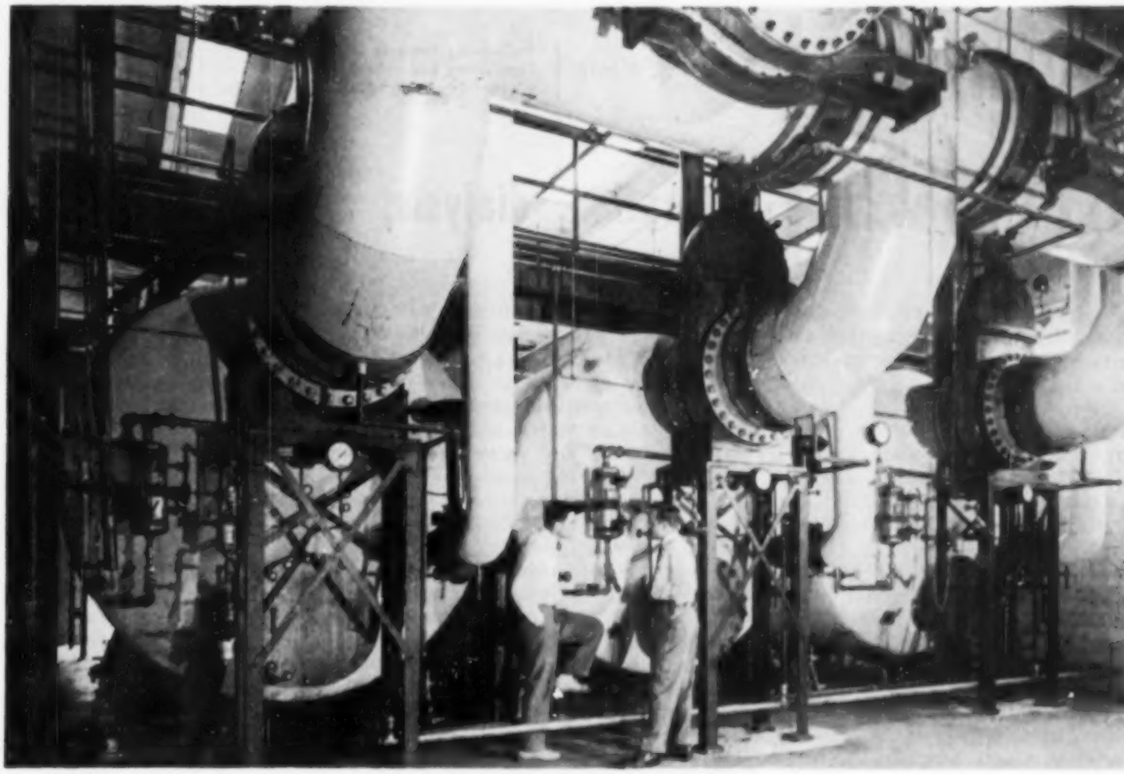


Fig. 11. View of activated carbon solvent recovery unit (see page 517). Photo courtesy Union Carbide.

PART 1

sorption processes

The large number of recent process and theoretical developments in adsorption, dialysis, and ion exchange have now brought forward such a large body of similarities that it may be possible to group these three fields into one. For convenience, the name "sorption processes" is suggested.

All of the materials involved in these processes are microporous in nature, and thus all act to limit mass transfer. In practice, the granular form of adsorbent, dialytic, and ion exchange materials can be used in fixed beds and the membrane form in a filter press type of equipment. The theoretical equations which can be developed for correlating the performances of these types of equipment are closely related.

Here is a report for the chemical engineer on significant developments—ranging in content from physico-chemical relationships to practical applications. It is hoped that this discussion may result in a wider consideration of these new correlations and that in the future an even more unified treatment of these fields will be evolved.

sorption processes

adsorption, dialysis, and ion exchange—

Gilbert P. Monet

Engineering Research Laboratory
Engineering Department
Du Pont Company, Wilmington, Delaware

Adsorption and ion exchange have steadily acquired increasing importance in the purification of gases and solutions. For example, adsorption is widely used in the drying of gases and in the recovery of solvent vapors. Ion exchange is used to soften water, to reduce dissolved solids in water to low levels, and to recover metals from solution. These applications are attractive because the adsorbent and ion exchange materials are most effective when used to remove small amounts of solutes from fluids. Three important factors in the exploitation of these materials are: (1) new applications can be evaluated simply, (2) scale-up to large-size equipment is not difficult, (3) plant equipment is essentially simple in design and construction.

Research workers in these fields recognize, however, that present techniques in common industrial use permit only gross separation of solutes rather than close fractionation; that often the adsorbent and ion exchange materials are used at a low level of service, in terms of solute removed per cubic foot per hour; and that a large number of new separations have been made for analytical purposes but are virtually unexploited as plant-scale operations. The most common method for contacting fluids with adsorbent and ion exchange materials is to use these materials batchwise as fixed beds. Although the operation is simple in practice, it is sufficiently complicated in theory that no answer has yet appeared to the question as to what is the best method for using a cubic foot of these materials. In fixed beds of ion exchange materials, usually only a portion of the bed is used at any one time to reduce the solute concentration in the feed to its effluent value and the cycle time is often 6-24 hr. Thus the resin is utilized to only a small value compared to that which might be attained were continuous countercurrent contacting apparatus available.

Table 1.
Timetable of Recent Unusual Separating Methods

1945	Gaseous diffusion process
1946	Hypersorption Multistage dialytic fractionation of crystalloidal solutes
1947	Ion exchange fractionation of rare earths
1949	Mixed-bed deionization Electrodialysis with ionic membrane barriers Natural molecular sieves
1951	Ion exclusion
1954	Synthetic molecular sieves
1956	Fluid Char process Higgins semicontinuous contactor Particulate gel dialysis
1957	Permeation of liquids through barriers Selective absorption in granules Ion retardation

With regard to new processes, Table 1 shows a list of processes which have appeared since 1945. There are more than twelve items in this list and probably only a few are familiar to most chemical engineers. To most of them it is possibly a surprise that this list includes references to processes employing membranes such as the "gaseous diffusion" process and electrodialysis. Also included are references to dialysis employing granular gels and to molecular sieve adsorbents. This list is not a complete description of possible adsorbent, dialysis, and ion exchange materials, nor does it include any of a wide variety of applications of these materials which can be found in technical reviews.

If one grants that exploitation of many of these new processes depends partly on further development of better materials and equipment, it can be argued that most of these processes are not used more commonly because there is a lack of basic knowledge about them on the part of process chemists and engineers. Obtaining such knowledge is not easy, however, because the literature in these fields is broadly scattered and large in volume. For example, the 1957 reviews of adsorption and ion exchange in one periodical include over 2,000 references!

One possible solution to the development of a working knowledge of these fields is to understand the similarities between these fields, as far as they have been or can be developed. In dealing with specific applications, then, the basic principles can be applied with suitable modifications. These similarities can be developed along the following lines: (1) the structure and form of the materials and, (2) the physicochemical and chemical engineering principles encountered in the use of these materials.

Similarity in Structure

Most of the important types of adsorbent, dialytic, and ion exchange materials have been shown to contain a significant amount of micropores. The micropores in adsorbent carbons, silica gel, and ion exchange resins range from about 15 to 150 Å diameter. Now such small pores prevent dissolved solutes of relatively large size such as dyes, color bodies, and proteins from entering these pores. This exclusion of large solutes and the sorption of small solutes is identical in principle to dialysis where cellulosic membranes are used to separate crystalloids from colloids having a diameter of 50 to 5,000 Å. It is largely for this reason that it is suggested that dialysis be grouped together with adsorption and ion exchange.

The microporosity of these materials naturally leads to a large specific surface and hence it is not surprising that ion exchange resins can adsorb nonelectrolytes and cellulose can adsorb dyes. It is also true that the chemical composition of adsorbents and cellulose can lead to the sorption of electrolytes just as for ion exchange resins.

The reciprocal properties of these materials extend even further. Dialysis not only includes separation of solutes by the size of the micropores in the membrane but also separation by solubility in the membrane. For example, a rubber membrane will sorb aromatics but not alcohols. Thus, solubility effects must be considered with the other properties of these materials.

One way of showing the interrelationships of the size selectivity of micropores, adsorption, dialysis (solu-

an introduction

bility), and ion exchange is portrayed in Figure 1. The significance of this figure is that all three types of materials can show size-selective effects arising from the small diameter of the micropores. In addition, adsorbents retain solutes on the surfaces of the micropores largely by physical forces, and ion exchange resins retain solutes by chemical forces. Dialysis is used to signify retention of solutes by solubility in the solid which is equivalent to solid absorption.

The title suggested for these relationships in Figure 1 is "Sorption Processes." The word sorption was coined long ago to describe the uptake of a solute by a solid where the mechanism could not be readily identified as ad- or absorption. The title appears appropriate not only because it is still difficult to identify the mechanism of solute uptake under some conditions with adsorbent, dialysis, and ion exchange materials, but also because ion exchange is linked historically to adsorption and dialysis sometimes involves absorption.

Similarities in Form

The classification of adsorbent, dialysis, and ion exchange materials according to their form is interesting not only because similarities in processing equipment can be recognized, but because new areas of processing are indicated. This classification is shown in Figure 2 and leads to the following results:

1. Granular adsorbents, granular ion exchange resins, and dialytic membranes are old.
2. Ion exchange membranes are recent.
3. Adsorbent membranes and granular dialytic gels *remain to be exploited.*

Subsequent papers in this symposium deal with items Nos. 1 and 2 above. Adsorbent membranes cannot be said to exist with certainty. It is generally agreed that a sorbable vapor can flow more rapidly through a plug of adsorbent carbon or a piece of microporous glass than will a fixed gas. Plastic membranes also show this behavior. Perhaps the most outstanding example of an adsorbent membrane process is the description given recently (*1*) of the selective permeation of liquid azeotropic mixtures placed on the upstream side of a membrane which is exposed to a vacuum on the downstream side.

With regard to granular dialytic gels, the basic idea is to prepare and use the cellulosic dialytic medium as small granules, the surface of which contains the size-selective pores and the interior contains a large volume of solvent capable of dissolving solutes which diffuse in through the surface. The advantage of this process is the large specific surface of small granules. The solvent content of the particle can also be large, 80% by weight in the case of regenerated cellulose. A schematic flow sheet of a process, employing such a granular dialytic medium in two continuous countercurrent contactors for the separation of a solution containing crystalloidal and colloidal solutes, is shown in Figure 3.

Similarities in Processing

The similarities in the facilities used for processing are probably more obvious and of greater interest than the similarities just described for the structure and form of the three types of

Fig. 1.—Sorption Processes.

ALL THESE MATERIALS ARE SIMILAR IN PORE SELECTIVITY (SIZE)	Adsorption materials (by physical forces) Dialytic materials (dissolve on surfaces) Ion exchange materials (by chemical forces)

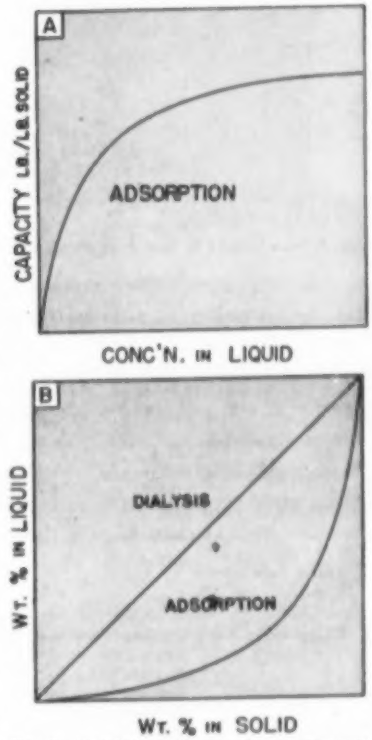


Fig. 5. Equilibrium diagram (one component dissolved).

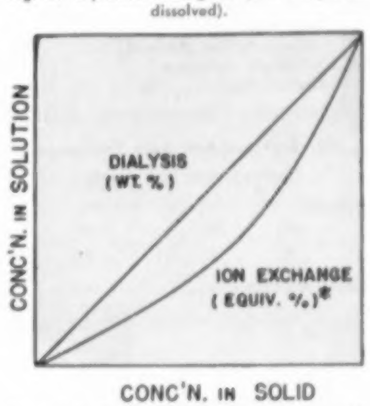


Fig. 6. Equilibrium diagram (two components dissolved).

* $(\text{Equiv. } \%)_A = (C_A/C_A + C_B)(100)$

C = normality, g. equiv./l.

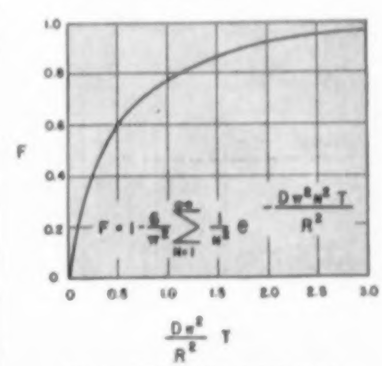


Fig. 9. Diffusion into porous solids.

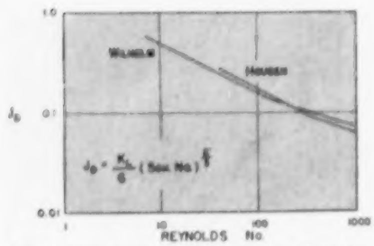


Fig. 7. Mass transfer in fixed beds of granules.

Fig. 2.—Availability of Solid Materials.

Form	Adsorption	Dialysis	Ion exchange
Granular	old	possible	old
Membrane	possible	old	recent

Processes: gas—solid, liquid—solid.

Fig. 4.—Contactors.

Granular materials:

1. Batch........... Slurry
   Fixed bed
2. Semicontinuous... Cascade slurry tanks
   Single bed
   Multiple bed
3. Continuous...... Cascade slurry tanks
   Hydraulic flow
   Mechanical flow

Membrane materials:

1. Filter press
   Concentration difference .... ΔC
   Pressure difference .... ΔP
2. Electrodialysis

Fig. 8.—Fixed-bed Rate Equations.

(Unsteady-state mass transfer)

Over-all:

$$V\frac{\partial C_L}{\partial L} = \epsilon\frac{\partial C_L}{\partial T} + (1-\epsilon)\frac{\partial C_s}{\partial T}$$

Liquid film controlling:

$$\frac{\partial C_s}{\partial T} = K_L(C_L - C_L^*)$$

Reaction rate controlling:

$$\frac{\partial C_s}{\partial T} = K_F(C_L)_A(C_s)_B - K_R(C_s)_A(C_L)_B$$

Solid diffusion controlling:

$$\frac{\partial C_s}{\partial T} = D_s\left(\frac{\partial^2 C_s}{\partial R^2} + \frac{2}{R}\frac{\partial C_s}{\partial R}\right)$$

materials. Figure 4 shows a tabulation of the various types of facilities which have been investigated or are in wide use for one or more of these three materials. The facilities are divided into two categories according to the granular or membrane form of the material being processed.

A. GRANULAR MATERIALS

Batch apparatus is used most commonly for granular materials. Finely divided carbons are contacted with solutions in an agitated tank. Fixed beds of ion exchange resins, carbons, and clays are most frequently encountered. Little work has been done on fixed beds of granular dialytic gels. However, it is believed that the facilities are essentially the same regardless of the type of granular material being used. Also fixed-bed operation is preferable to a single slurry contactor from the standpoint of efficiency of utilization of the solid material if the equilibrium between the solid and the solution is readily reversible.

Continuous contactors, such as the "Hypersorber" and the "Fluid Char" process, have been developed for contacting carbon with gases. It would seem possible to use other granular solid materials in these facilities subject to the same limitation as carbon, that is, where the solid can maintain appreciable capacity in cyclic operation and where the material is resistant to attrition.

A variety of continuous contactors has been suggested for contacting ion exchange resins with solutions, but none have been particularly attractive. The low density of the particles limits the range of devices where the solid settles through rising stream of solution. The complexity and high cost of mechanical devices for conveying granular solids countercurrent to solutions has limited interest in these devices. One novel apparatus for accomplishing essentially continuous and countercurrent contact is the semicontinuous Higgins contactor. Recent progress in the development of this contactor is reported in the session on ion exchange (*3*). While most contactors have been investigated for use with ion exchange resins, some development work has been done using granular carbons. Again, no change in the form of the contactor appears to be required for different types of granular materials.

B. MEMBRANES

At present, the Brosites dialyzer is widely used for dialyzing solutions of caustic soda and hemicellulose in the manufacture of rayon. A vegetable parchment paper is used as the membrane, and the apparatus resembles a filter press with frames about ½ in. thick. The electrodialyzer for ionic membranes developed by Ionics Inc., which is described in the membrane session (*5*), also resembles a filter press except that in order to obtain more membrane area between the terminal electrodes, the frames appear to be only about 1/16 in. thick. No description has been published of the gaseous diffusion barrier assembly. It can only be guessed that microporous and adsorbent barriers will also require facilities resembling a filter press since separate feed and product compartments are needed and some means of supporting the membrane is required. Again the apparatus appears to be identical in principle for the three membrane materials, differing only in construction depending on whether mass transfer is accomplished by a concentration, pressure, or electromotive force difference.

Similarities in Physical Chemistry, Chemical Engineering

Similarities can be traced in the measurement and correlation of such physicochemical properties as micropore size and distribution, equilibrium between a granular solid and a fluid, the diffusivity inside granular microporous solids, and the selectivity and mass transfer rate through membranes. It should be emphasized that while such similarities can be found, it is not meant that adsorption, dialysis, and ion exchange are the same. As pointed out previously, the forces causing retention of a solute by the solid are widely different in each case.

It should also be pointed out that systematic measurements have not been made of the microporosity of all types of materials available. The most progress has been made for granular materials having a micropore structure when dry. For materials such as ion exchange resins which develop most of their microporosity on swelling in water, only the exclusion of

Fig. 3. Flow diagram, particulate gel dialysis.

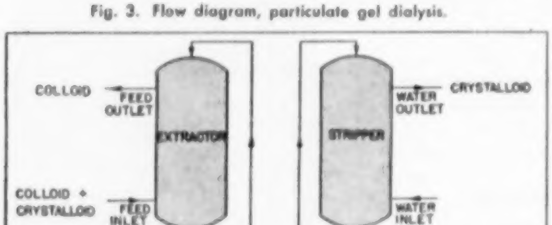
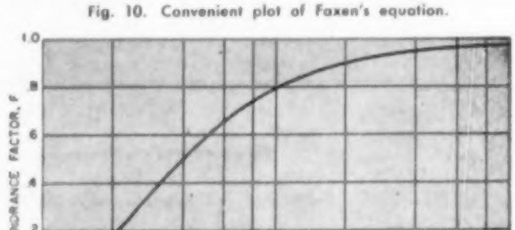


Fig. 10. Convenient plot of Faxen's equation.



dyes of different sizes has been used for measurement.

With these reservations in mind, similarities in chemical engineering are still obvious. For example, given a continuous countercurrent contactor and one of the various equilibrium diagrams shown in Figures 5 and 6, the number of transfer units can be calculated by standard methods. Also if one assumes mass transfer in the fluid to be limiting, the height of transfer units can be calculated by standard methods. Also if one assumes mass transfer in the fluid to be limiting, the height of transfer units can be estimated from *j*-factor correlations such as shown in Figure 7.

Since continuous countercurrent contactors are not commonly used, what can be done about fixed-bed contactors? Here again, the various basic mathematical equations are the same for beds of adsorbents and ion exchange resins, as shown in Figure 8. Exact solutions are possible for simple equilibrium diagrams and where mass transfer in the fluid film is controlling. The real problem is to obtain exact solutions allowing for resistance in both the fluid film and the solid.

A general approach to the measurement of the diffusivity inside microporous solids appears possible from equations previously solved for heat transfer (*2*). The degree of saturation of an ion exchange resin vs. time of exposure to a solution of given concentration is shown in Figure 9. From the parameters of this curve, the diffusivity inside the solid can be calculated. Diffusivities measured in resins have ranged downwards from a value of about one-half the value in free solution. The higher the cross-linking of the resin and the smaller the size of the micropores, the lower is the diffusivity in the solid. An interesting method for allowing for the drag of the micropores on the diffusing solute is suggested in the membrane session (*4*) and is reproduced in Figure 10. The smaller the micropores, the less is the hindrance factor, and the lower is the diffusivity in the micropores.

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sorption processes

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granular processes—adsorption

Adsorbents are of inestimable value in the manufacture of chemicals because of their ability to remove color from solutions. Bone char is used to decolorize sugar syrups on a very large scale. As many as 20 to 30 beds, each containing 1,000 to 1,500 cu.ft. of char, are required to treat 2,500 tons of sugar daily. The decolorization of lube oils by beds of clays is another important application carried out on a scale about as large as that for sugar. There are a large number of small-scale installations where finely-divided carbons are used as a slurry to decolorize solutions. Also, beds of granular carbon containing many hundreds of cubic feet (see Figure 11, p. 513) are used to recover solvent vapors from air. The adsorbent materials used—carbon, clay, silica gel, etc.—are all known to have specific surfaces of 20 to 2,000 sq.m./g. Despite the large amount of research published on adsorption, the forces involved in adsorption remain obscure.

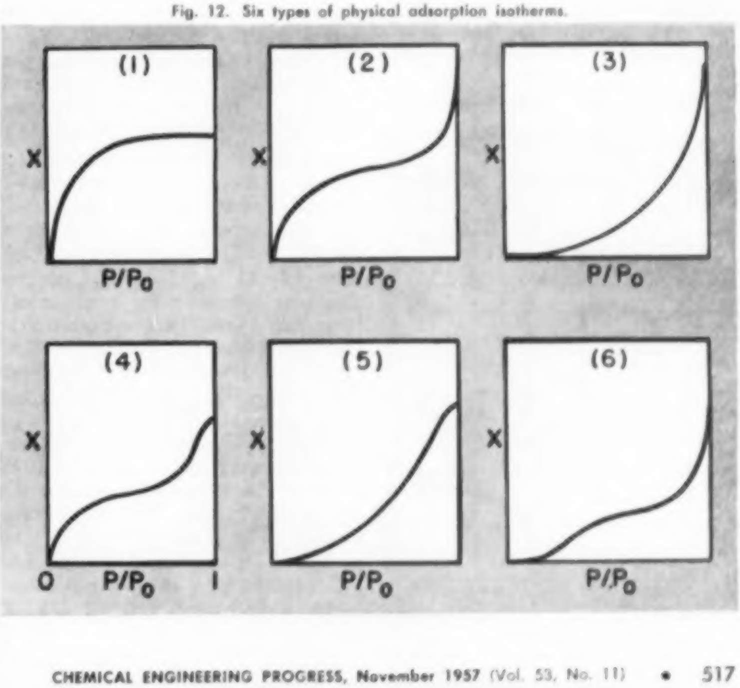
A unified picture of the nature and energy relationships of adsorption has recently been described by Graham of Du Pont (*1*) in simple terms so as to give the chemical engineer unfamiliar with this subject a working knowledge. Included are the concepts of physical adsorption and chemisorption (chemical-type bonding), with emphasis on the types of bonding and the heats of adsorption.

As adsorption of gases has been the subject of most of the basic research, this theme occupies a major portion of the field as reviewed by Graham. To permit a better understanding of the mechanisms involved, six known types of isotherms have been plotted (Figure 12) and compared. The classical equations which analytically represent certain of the isotherms (including those of Langmuir and Freundlich) have been recompared and their general applicability observed.

Further insight into the mechanism of adsorption of nonideal gases is shown by plotting the isotherm in terms of the fraction coverage of the surface, as shown in Figure 13.

The more important types of indus-

Fig. 12. Six types of physical adsorption isotherms.



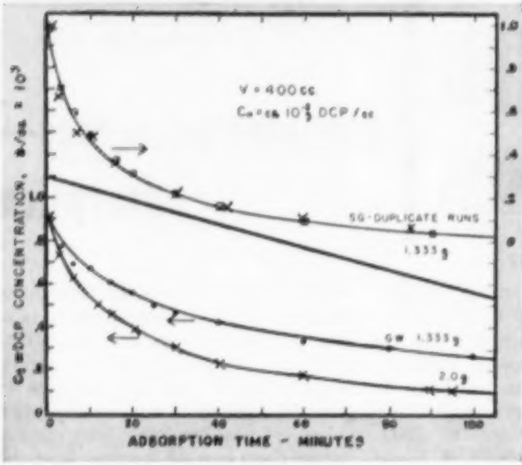


Fig. 14. Shallow-bed rate data.

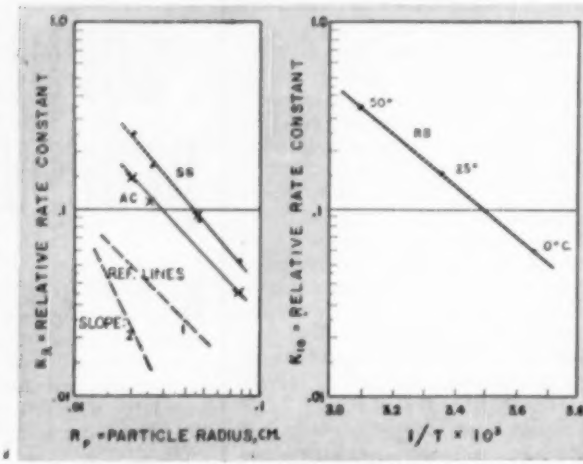
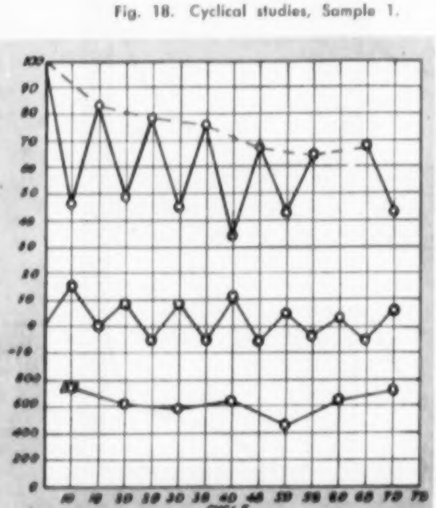


Fig. 15. Rate of solute removal.

trial equipment used for contacting granular adsorbents with fluids, including the batch fixed-bed and continuous countercurrent contactors, have also been classified and reviewed by Graham.

An attempt has been made to measure the rate of diffusion inside a granular microporous carbon by S. B. Smith and others (*2*), Pittsburgh Coke and Chemical Co., for the purpose of obtaining data on which could be based the rational design of fixed-bed equipment for contacting granular carbon with solutions. The experimental method was to follow the rate of removal of solute in a solution circulated past a shallow bed of various types of carbon. In order to demonstrate the significant effect of diffusion of the solute in the solid, a comparison was made of the time required to reduce the solute to a given level by:

Fig. 18. Cyclical studies, Sample 1.



(1) continuous contact with the solution and,

(2) by a number of stepwise contacts with the solution, allowing time between steps for diffusion to occur inside the carbon particles in the absence of the solution.

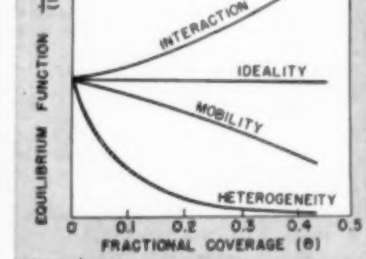
The time required to obtain the same end results was 3 to 4 times longer for continuous than for stepwise contact! It is to be concluded, therefore, that knowledge of solid diffusion is essential in order to allow adequate contact time for solute depletion in a carbon bed.

The rate data on the shallow bed (Figure 14) could not be correlated directly by the theoretical equations of Dryden and Kaye until modified by the introduction of exponents derived by graphical treatments. As an example, the rate of solute removal was inversely proportional to the first power of the diameter of the carbon granule rather than the second power as expected (Figure 15). It was concluded that this correlation gave a reasonable fit to the data obtained and that it is expected to be applicable to other carbon solute systems.

One of the most important areas of recent chemical engineering research in adsorption is seen by Baddour of M.I.T. and Geddes of Stone & Webster (*3*) to have been the development of equipment for granular carbons with gases by continuous countercurrent methods. Union Oil Company has introduced the "Hypersorber," Figure 16, in which a bed of carbon moves downward through a gas stream. Esso Research and Engineering Company has investigated the "Fluid Char" process for contacting gases with carbon. The carbon is contained in a series of fluidized beds which move downward through what is essentially a sieve-plate column with downcomers (Figure 17). In both contactors other granular solids besides carbon could be used, providing they are resistant to attrition. Quite naturally, both contactors have found extensive use in the treatment of hydrocarbon gases. One of the important problems is to minimize adsorption of unsaturated compounds to prevent reduction of adsorbent capacity during cyclic operation. The same problem occurs in using batch fixed beds of carbon.

Small fixed beds of carbon have been exposed to a large volume of a gas produced by propane pyrolysis and containing about 19 per cent ethylene. The resulting activity of the carbon was obtained by measuring the amount of ethylene gas adsorbed under standard low temperature conditions. In all cases, a loss in carbon activity resulted from contact with the pyrolysis gas. Various high temperature steam-stripping treatments were then used to desorb the carbon. In cyclic operation, it appears that the carbon activity decreases to 50-70 per cent of its initial value when the carbon is desorbed with steam at 500° F. and then burned with steam at 1,400° F. (Figure 18).

Fig. 13. Effects of individual nonideality factors upon the equilibrium function.



The introduction of synthetic inorganic adsorbents called "molecular sieves" has been one of the most important practical advances in adsorption in the past decade, according to Griesmer and others of Linde Air Products Co. (*4*). Naturally-occurring minerals, such as chabazite, have been known to function as molecular sieves, in that they were able to occlude and exclude gas molecules of 4-6Å diam. The synthesis of such materials has resulted in a wider range of pore selectivity at wide commercial availability. The most important property seen commercially to date is their extraordinary capacity to adsorb water vapor from gases at very low dew points. The potential of these materials to separate solutes on the basis of size has not yet been exploited significantly, at least according to published data.

Molecular sieves are today synthetic sodium and calcium alumino-silicates with extremely well-defined openings to cavities in their crystal structure, as seen in the atom model in Figure 19. Table 1 shows that classes of molecules are either occluded or excluded on the basis of the dimensions of the cavity openings and of the solute molecules. Some of the present and potential applications of molecular sieves are the drying of air and nonpolar liquids, the sweetening of natural gas, and the removal of carbon dioxide from ethylene. A typical breakthrough curve of water vapor from a molecular sieve bed is shown in Figure 20 along with curves for silica gel and alumina gel for comparison. Important new developments are foreseen for the future when materials having pore diameters of 3, 10, and 13 Å are commercialized.

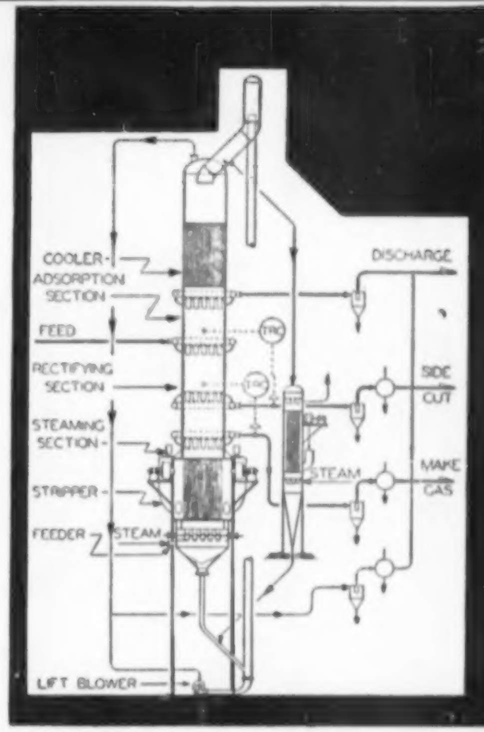


Fig. 16. Diagram of Hypersorption unit.

Table 1.—Comparative Equilibrium Adsorption Capacities

Adsorbate	Partial pressure mm. Hg	Weight per cent adsorbed: 5A Molecular sieve	Silica gel	Activated Carbon
n-Butane	47	9.8	3.4	23.8
i-Butane	98	<0.5	4.8	25.9
Benzene	50	<0.5	34.2	43.7

Temperature: 77° F.

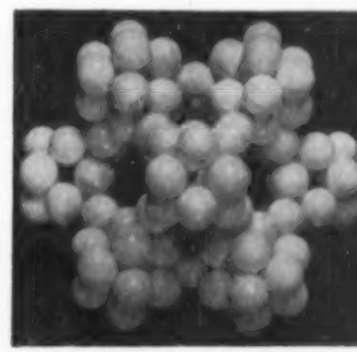


Fig. 19. Molecular sieve "A" crystal model.

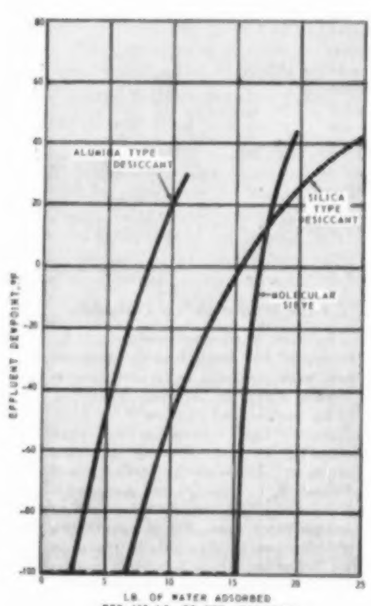


Fig. 20. Dynamic water adsorption capacities, adiabatic drying of air. Bed depth, 30 in.; air velocity, 40 ft./min.; inlet air temp., 80° F.; inlet relative humidity, 80%; pressure, 1 atm.

Coming this Spring

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SORPTION PROCESSES

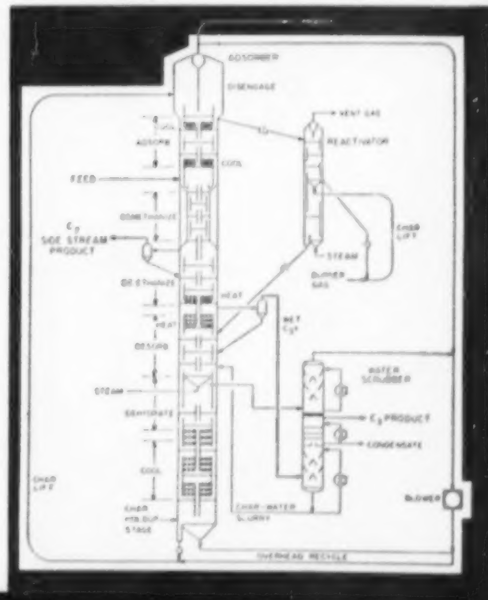
A complete collection of the papers which provided the basis for the accompanying article will be published soon in paper binding and will be available at nominal cost.

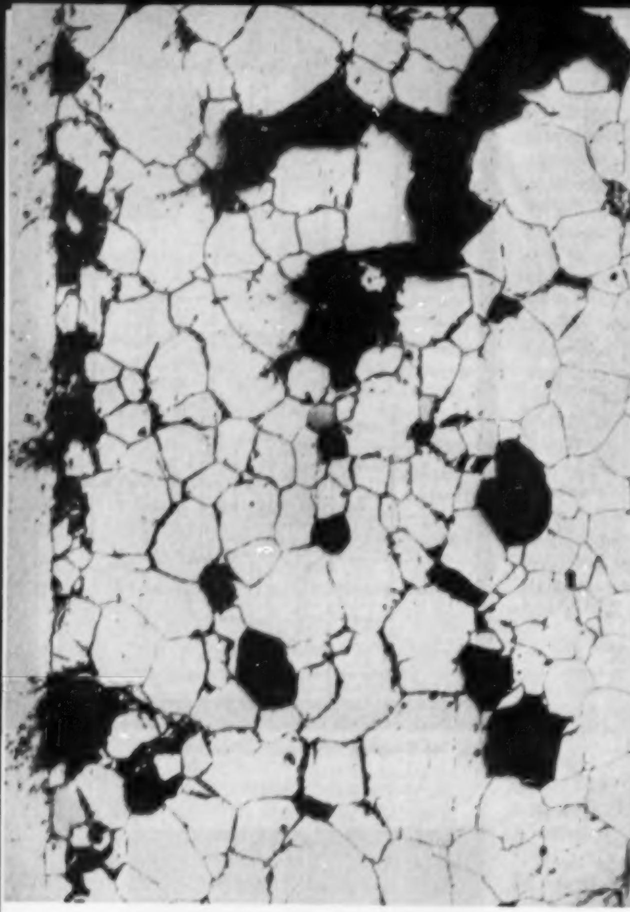
Literature references cited by author Lapidus in the accompanying article correspond to chapters in the coming volume as follows:

1. Graham, D. P., "Adsorption Equilibria."
2. Smith, S. B., A. X. Hiltgen, and A. J. Juhola, "Kinetics of Batchwise Adsorption of Dichlorophenol on Activated Carbon."
3. Baddour, R. F., and R. L. Geddes, "Deactivation Phenomena During Charcoal Adsorption of Hydrocarbon Gases."
4. Griesmer, G. J., R. A. Jones, and H. Lautensack, "Molecular Sieves."

Also, in the same volume, and to be interpreted next month by authors Selke and Winger, are papers on ion exchange equilibrium and kinetics relationships, contacting equipment, rare earth separation process principles, gaseous diffusion, dialysis, ultrafiltration, and combined ion-exchange and dialysis.

Fig. 17. Commercial fluid adsorption design.





This severe intergranular corrosion occurred in a piece of Type 316 stainless piping in sulfite pulp mill service. Pipe had been improperly heat treated before placement in service.

CORROSION

In a general treatment of the question of corrosion in chemical engineering experience, the author outlines a sound engineering approach toward effective investigation procedures, practical corrective measures, and points out some common pitfalls.

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Intergranular corrosion occurred on one side of weld in dust collector fabricated of Type 316 stainless. Corrosive medium was acid slurry in fertilizer plant. Analysis showed 0.077% carbon present in sheet suffering severe intergranular attack. Other sheet had 0.042% carbon.

Basic Literature on Corrosion

In recent years much useful basic information has been brought together and made available in several comprehensive works on corrosion by Evans, Uhlig, Speller, and Fontana (1, 2, 3, 4). Corrosion rate information has been compiled for each of many individual corrosion substances by Nelson, and Rabald (5, 6). Lee (7) has prepared a text on materials actually being used to handle more than 300 chemicals and combinations of chemicals in the process industries. These important sources of data are set off here to provide information of a general nature for the benefit of the reader. Many additional references will be found in Literature Cited at the end of the article.

The study of corrosion is an intriguing and complex offshoot of the work of chemical engineering. It is a field of interest, one of unexpected developments. Its activities, always increasing and broadening, thus require more and more engineers.

This article deals primarily with procedures in investigating corrosion failures in the plant, and also with practical methods of mitigating corrosion when original materials have failed. It points out pitfalls to avoid when one undertakes corrosion investigations.

Corrosion can become a serious problem in three different ways: (1) it can lead to premature failure of equipment, (2) it can create an unsightly appearance, (3) it often, even in the mildest form, can breed product contamination. Where purity is essential, contamination can be as disastrous as equipment failure.

As in any other inquiry, the logical steps to follow simply involve gathering the facts, relating one to the other, and drawing conclusions. An examination of an individual plant failure will testify to the practical sequence of these steps.

problem-solving methods and materials

The Engineering Approach

An investigation on corrosion indicates first the need to assemble all the possibly significant operating data of the type shown in Table 1.

Data on the corrosive medium should include information regarding *p*H, principal substances, impurities, viscosity, and suspended solids. Conditions of exposure should be indicated as continuous, intermittent, or variable. Temperature variations should include minimum, maximum, and average values. Motion in the system should be described as quiet, agitated, or flowing. Relative areas of dissimilar metals should be estimated. Stress conditions should be described as variable or constant; high, moderate, low; whether in compression, tension, or shear. Once these facts are assembled, further steps can be more effectively taken.

An early step is of course the visual inspection.

If corrosion products or other deposits are present, it is often advisable to scrape off a sample before cleaning corroded equipment for later phases of the work. Moist samples should be held in small glass containers rather than in paper envelopes. If photographs are desired, the first one should be taken before the piece is disturbed. If corrosion products are not present, serious consideration must be given to the possibility that mechanical failure is at fault.

When the surface of the equipment has been washed free of deposits, another photograph may be desirable. It is best to take this picture before the surface is appreciably scratched or disturbed. However, if areas are to be cut from the surface later, the surface should be clearly marked before photographing to show where cuts will be made.

At this stage it is well to see if the metal or alloy is the material it is supposed to be. A quick check with a magnet, a spot test, or other identification test may be revealing. A magnet is useful, for example, to distinguish an austenitic stainless steel from a ferritic or martensitic type.

There are a number of chemical spot tests that aid rapid identification. Sparking characteristics and hardness help separate alloys. Suppliers of metals publish procedures (*8, 9*). Mixups in materials can occur and sometimes a corrosion problem is solved here, saving much time and effort.

Once the form of corrosion is determined, it is also possible that the investigation has gone far enough and corrective measures can be taken. Close inspection of the cleaned surface will often, but not always, reveal the specific type of corrosion. Useful aids for close inspection are a movable light source, small probe, hand magnifying glass, or portable microscope.

Fontana (*4*) lists eight forms of corrosion classified according to the appearance of the corroded metal (Table 2) and a number of additional forms are given in Table 3. On all these forms a considerable amount of information is available in the literature.

A metallographic examination is necessary in studying a corrosion failure in order to confirm the presence of such phenomena as intergranular corrosion, corrosion fatigue, stress corrosion cracking, and also to identify various high temperature effects. At the same time the metallograph gives information on type of structure present, effect of heat treatment, and presence of undesirable precipitates or constituents.

Chemical analysis of a metal or alloy that has failed is generally limited to determining the principal elements. This will establish the specific grade involved. In some cases, within an alloy grouping, analysis for a single element may be enough to distinguish between two or more types, as indicated in Table 4. Where adequate methods and equipment are available, identification of grade may be made rapidly with the spectrograph.

Chemical analysis of a corrosion product may or may not be of value. In the case of stainless steels, a qualitative analysis for chlorides is desirable. Presence of chlorides in an environment often can explain etching or pitting. Sulfates also are significant at times. Yet in general, it is often advisable not to proceed too far with analyses of corrosion products.

Corrective Measures

There are many possibilities in the way of corrective measures to lessen or eliminate a corrosive condition.

CHEMICAL COMPOSITION

The types of corrosion and the analysis of the process stream may indicate that only a simple change in a process chemical is required. Where practical, substitution of one acid for another or one salt for another may mean the difference between rapid failure and long satisfactory service.

DESIGN

Probably one of the most important factors influencing corrosion failures is faulty design. Too often the tendency is to disregard the detrimental effects of built-in crevices, notches that serve as stress-raisers, contact with moisture-absorbing material, and dissimilar metals. The relation of design to failure and the possibility of a corresponding change should not be overlooked. The recent literature covers recommended procedures (*10,11,12,13,14,15*).

INHIBITORS

Again, the analysis of the process stream may indicate the addition of a small quantity of certain substances to arrest corrosion of an alloy. Neutralizing amines or film-forming amines introduced into steam condensate systems prevent corrosion by entrained carbon dioxide. Cupric and ferric ions prevent corrosion of stainless steels in sulfuric acid. Polyphosphates, chromates, formaldehyde, and other sub-

Table 1.—Operating Data Useful in Corrosion Investigations

Corrosive medium	Agitation
Conditions of exposure	Aeration
Temperature variations	Dissimilar metals
Pressure variations	Stress present

stances too numerous to mention find wide use in water systems, oil wells, and process streams. Vapor-phase inhibitors prevent corrosion of ferrous materials by humid air and are widely employed in the packaging field. Inhibitors are often considered an economical solution to a corrosion problem. This subject of inhibitors, of special interest to engineers, has been covered in basic texts on corrosion, but many new developments are described in the recent literature.

CATHODIC METHODS

In another corrosion prevention procedure the metal to be protected can be made the cathode in a system where one or more anodes are electrically connected to it. The process stream or other medium involved serves as the electrolyte. The current flow can be maintained by sacrificial anodes of zinc, aluminum, or magnesium; on the other hand, carbon, Duriron or platinum anodes can be employed. With these latter types the current must flow from a d.-c. power supply. The resulting cathodic protection can be effective in systems where the metal to be protected is totally immersed or buried. Cathodic protection methods and materials have reached an advanced stage of development and it is well to seek the advice of competent specialists in the field.

COATINGS

Another field of corrosion prevention in which progress is being made is that of protective coatings. This field should rightly be divided into several sections: metallic coatings, organic coatings, glass and vitreous enamels, and masonry and allied materials.

Ellis *(16)* recently covered developments in the field of hot dipped zinc and aluminum coatings on sheet steel which find wide service as building coverings in the process industries. Kimberly *(17)* gives a description of zinc coatings of all types and discusses the effectiveness of zinc in the atmosphere. Hot dipped aluminum applied after fabrication is now being used in petroleum refining equipment *(18)*.

Corrosion Testing

In perhaps the majority of cases the chemical engineer will be looking for the right metal for the job. His first inclination will be to conduct tests. He must realize, however, that much valuable information on metals and alloys is already available and a review of this is often justified. Metal suppliers have much useful and unpublished data in their files. Where definite data are not available, a corrosion test is required. If corrosion tests are to be performed, they must be practical.

Parker *(19)* states that corrosion rates can be determined in the following ways:

- direct observation
- specimens inserted into vessels or piping
- laboratory tests
- observation of auxiliary effects.

It has been pointed out *(20)* that a number of tests have been developed and the principal ones are:

- laboratory tests, including inspection
- plant tests
- field tests—exposing samples to the atmosphere, soils, natural waters; and
- service tests, with a material for part of some operating equipment, such as an evaporator tube, or for small-scale pilot equipment.

Combining these listings one finds that there are at least a half dozen general methods of determining corrosion rates and thereby suitable materials of construction. These methods and others outlined by LaQue and Knapp *(21)* and Champion *(22)* provide valuable information on procedures.

A "coupon technique" of testing is practiced in the petroleum industry. Changes in corrosion characteristics of a fluid are determined by effects on small standard coupons. Bilhartz and Greenwell *(23)* have described in detail the steps they follow with this method.

A development now finding practical experience is the corrosion testing technique involving measurement of changes in electrical resistance of a specimen. Dravnieks and Cataldi *(24)* point out that the main value is in establishing the relative corrosivities of media which are closely alike.

A recent adaptation, described by Freedman, Troscinski, and Dravnieks *(25)*, involves continuous monitoring of corrosion rates in refinery equipment without interrupting normal operations. It is reported that corrosion rates have been determined quantitatively in a few hours as compared with months required for coupon measurements, water analyses, and unit inspections.

Part of the Armco atmospheric corrosion testing facilities at Middletown, Ohio, where an estimated fifteen to twenty specimens are exposed to a mild industrial atmosphere.

Installation of culvert field test sections in ditch handling acid mine water. Pipe consists of short sections of numerous materials, each insulated from the other.

Table 2.—Corrosion Classified According to Appearance of Corroded Metal (4).

Concentration cell	Pitting
Dezincification	Stress corrosion (Season cracking) (Caustic embrittlement)
Erosion-corrosion	
Galvanic	
Intergranular	Uniform

Table 3.—Additional Forms of Corrosion

Bacterial	(Nitriding)
Cavitation erosion	(Scaling)
Filiform	(Sulfidation)
Fretting	Passive-active cell
Graphitic	Stray current
High temperature effects	Stress corrosion
(Carburization)	(Stress corrosion cracking)
(Liquid metal penetration)	(Corrosion fatigue)
(Mass transfer)	(Hydrogen and stress)

The choice of materials to include in a corrosion test is often a problem. Prange groups materials into three categories:

1. those commonly used in commercial equipment and which are readily fabricated.

2. those that can be fabricated into various parts, but are somewhat difficult to work or are expensive at first cost

3. those applicable only with difficulty at high cost.

Such groupings, kept current, might well serve as an over-all guide for materials to include in a test.

Ellis (*26*) points out that the evaluation of corrosion data by statistical methods often is desirable in order to obtain maximum useful information. He discusses a graphical method for a multiple correlation analysis involving several variables and illustrates the method with a study of weight loss data from an atmospheric exposure of low alloy steels. Lewis (*27*) discusses some basic concepts of statistical thinking and describes a graphical solution to the problem of estimating universe values from the sample values.

The calculation of corrosion rates is described several places in the literature (*4,20,23*). In addition Szymanski (*28*), and Bass and Andrews (*29*), have published nomographs that serve as aids in making calculations. It must be realized, however, that numerical designations of rates as mills per year, inches per year, milligrams per square decimeter per day, and the like, are accurate only to the extent that the corrosion is linear with time. Such calculated rates may be worthless when pitting is encountered.

Pitfalls

As a chemical engineer goes more and more into the corrosion of metals, he finds there are many pitfalls to sidestep. These are of such interest and importance that at least a few should be pointed out.

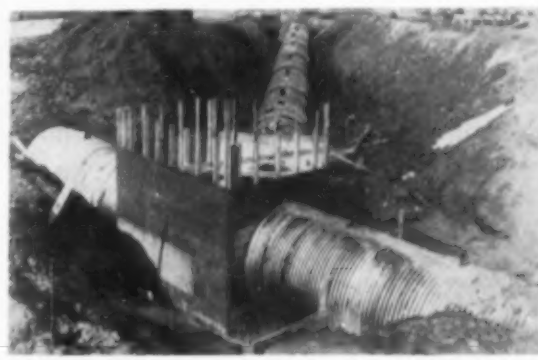
The corrosion engineer must realize that the e.m.f. series is different from a galvanic series. The former is based on potential measurements of metals in solutions of their own salts; on the other hand, the latter is a listing of potential measurements made in one corrosive medium; sea water is an example. Relative positions of metals are not necessarily the same in both series.

Accelerated corrosion of one metal in electrical contact with another in an electrolyte is called galvanic corrosion. But just the fact that two dissimilar metals are in contact does not necessarily mean that rapid failure of one will occur. It must be remembered that the presence of an electrolyte is necessary before attack can occur. Also polarization of one or both metals in the couple can slow down or stop corrosion. Whenever galvanic corrosion is suspected as the cause of failure, the system should be studied further to be sure that another cause is not responsible.

Sometimes a possible corrosive medium exists in a system subject to fatigue, and failure occurs. The corrosion engineer must realize that at least three types of failure are possible under such conditions: stress corrosion cracking, corrosion-fatigue, and ordinary fatigue. There have been cases where ordinary fatigue with no corrosion effects was the sole cause of failure. Design changes will often eliminate this trouble without resorting to corrosion prevention steps.

Extreme care must be used in expressing the results of an accelerated

In a mild industrial atmosphere a one-ounce aluminum coating on steel for plant buildings outlasts a zinc coating of similar weight at least 30 to 1 before painting is required.



Industrial waste sewer pipe is zinc-coated steel plus bonded-in-zinc asbestos fibers filled with bituminous saturant. Final coating is asphalt outside and inside.

Table 4.—Principal Elements for Metals Identification Purposes

	Nominal percentages							
	Al	Cu	Zn	Cr	Ni	Mo	Other	
3003 aluminum	Base						1.2 Mn	
3004 aluminum	Base						1.2 Mn	1 Mg
Red brass		85	15					
Naval brass		60	39.25				0.75 Sn	
Monel		30			67			
K Monel	2.75	29			66			
Type 304 s.s.				18	8		0.08 Max. C	
Type 316 s.s.				18	12	2.5	0.08 Max. C	
Type 347 s.s.				18	10		0.08 Max. C	Cb:10XC Min.

test in terms of expected service life under actual operating conditions. In most cases this is impractical or impossible.

For example, a 1-oz. continuously coated galvanized steel sheet can be expected to endure about 200 hr. in a 20% salt spray before showing evidence of red rust. The same sheet will endure about six years' exposure to a mild industrial atmosphere at Middletown, Ohio, before showing red rust spots, and more than eleven years in a marine atmosphere at Kure Beach, North Carolina. In a severe industrial atmosphere the time may be in the order of two years, whereas in a rural atmosphere the life will be much longer than in any of the others. So it can be seen that the salt spray test is no indication of what to expect of the sheet under various service conditions.

A laboratory test conducted by simple immersion of the specific metal in a corrosive medium at a given temperature might be misleading if, under actual service conditions, the same corrosive medium is kept hot by heat transfer through the same metal.

In other words, a steam coil imparting heat to a corrosive solution can be expected to be operating under much more severe conditions than the sidewall of a tank holding the same solution. The surface of the steam coil will attain a much hotter temperature. This hot wall effect must not be overlooked.

A minor impurity in a continuous process stream can be a major cause of corrosion. Yet this fact might be overlooked in a corrosion test employing beaker test quantities of the same corrosive medium. In the former instance, the minor impurity is constantly replenished; in the latter, it is used up quickly.

A Summing Up

1. The literature is extensive.
2. Procedures are logical.
3. Tests should be practical.
4. Avoid pitfalls.
5. Group action is effective.
6. A plant corrosion specialist is a valuable asset.
7. Outside help is available—try supplier first.

When underground applications are considered, it must be remembered that one type of soil may not have the same effect on metals and alloys as other types. There are a great many soil types over the country and relative corrosivity varies to a marked degree, even in close geographical proximity.

In preventing corrosion of one metal, one must give serious thought to the effect that corrective measures will have on various other metals in the system. For example, ammonia injection in refinery piping can reduce corrosion of iron but will lead to accelerated attack of copper alloy valves and fittings. Cathodic protection can be used to protect a pipeline or the interior of a tank. The item protected becomes the cathode, where hydrogen is discharged. If this cathode is subject to hydrogen embrittlement and stresses are present, cracking may occur.

When substituting a more corrosion resisting alloy such as a stainless steel, copper alloy, aluminum alloys, high nickel alloy, or the like, an investigator must give care to the particular grade chosen. The number of alloys available today is extremely large and each is designed for a specific condition or set of conditions. Care must be taken also to select the right composition within a family of alloys.

Wide-Interest Problems

If a corrosion problem has been commonly encountered, it may be possible to get information from a special technical group, such as the NACE committee on Sulfide Corrosion at High Temperatures and Pressures in the Petroleum Industry, and the API panel on Reformer Corrosion. Also through several of its committees ASTM has been conducting atmospheric corrosion tests at many locations over the country. This Society sponsors symposia on corrosion or on subjects closely allied to it (see *30*). Both the NACE and the ASTM have done considerable work in studying developments in organic coatings, glass, vitreous enamels, masonry, and the like for the benefit of the engineer. Mention should be made of the National Bureau of Standards' soil corrosion studies since 1910 and its stress corrosion cracking program with which industry cooperates. The Sea Horse Institute and other meetings at the International Nickel Company's test facilities at Harbor Island and Kure Beach, North Carolina, are a source of practical corrosion information.

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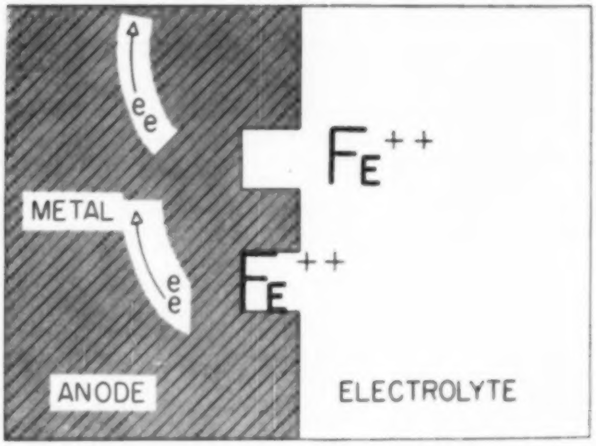

Fig. 1. Iron ion forms and leaves two electrons.

CORROSION

and its manifestations

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The initial purpose of this article is to provide the chemical engineer with a simplified and concise picture of corrosion.

Corrosion is the result of electrochemical or chemical reaction between a metal and its surroundings. The main requirements are actually simple and many corrosion problems can be solved based on these fundamentals (*1*).

A great majority of the corrosion costs are due to corrosion in electrolytes, which can be called *wet* corrosion. The first requisite conditions for electrochemical corrosion are that (1) anodes and cathodes must be present to form a cell, and (2) direct current must flow. The anodes and cathodes can be close together (local cells) or far apart. The current can be self-induced or it can be impressed on the system from an outside source.

The anode is the area where corrosion occurs and where the current leaves the metal; the cathode is the area where practically no corrosion occurs and where current enters the metal. Anodes and cathodes can form on a single piece of metal because of local differences in the metal or differences in the environment.

Local differences in a given metal can be chemical or mechanical in nature. Examples are: impurities such as oxides and other inclusions, grain boundaries, orientation of grains, differences in composition of the microstructure, localized stresses, and scratches and nicks. Highly polished surfaces are used in special cases. Very pure and very smooth zinc will not corrode in very pure hydrochloric acid because anodes and cathodes do not form. Yet we all know their commercial counterparts react rapidly. However, pure metals are not often used because they are expensive and have relatively low strength.

The metal at the anode dissolves and becomes an ion, as shown schematically in Figure 1 for iron. The iron atom loses two electrons which are left behind in the metal. These electrons travel to the cathode where they are accepted by hydrogen ions which become hydrogen gas, as illustrated in Figure 2. Current flow is opposite to

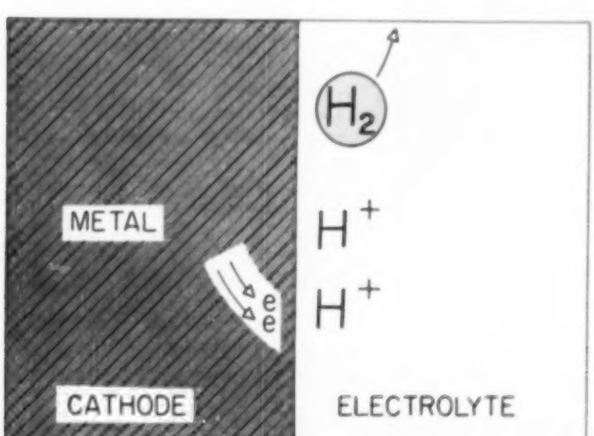
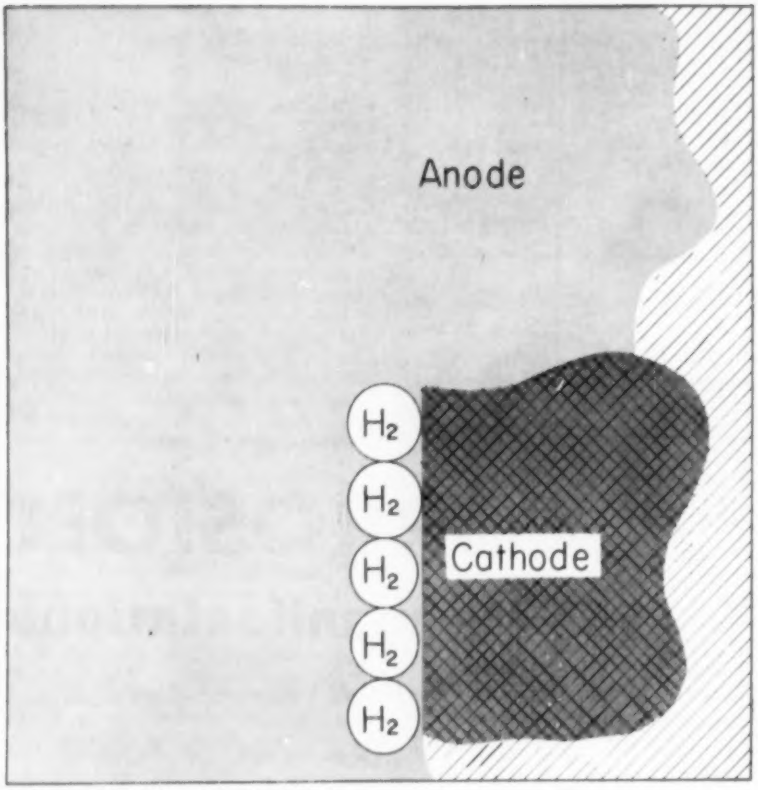
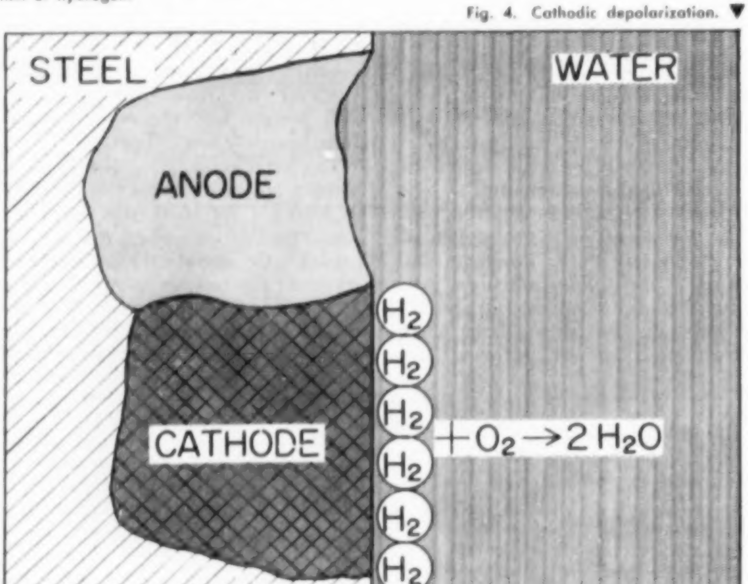


Fig. 2. Hydrogen forms on cathode.



▲ Fig. 3. Polarization of local cathode by a film of hydrogen.

Fig. 4. Cathodic depolarization. ▼



electron flow. A conductive solution or electrolyte is needed to complete the circuit. The current leaves the metal at the anode, flows through the solution to the cathode, and then passes through the metal from the cathode back to the anode, thus completing the circuit.

The reactions for corrosion of iron in pure water (and acids) are as follows:

$Fe - 2e = Fe^{++}$ (oxidation or reaction at the anode)

$2H^{+} + 2e = H_2$ (reduction or reaction at the cathode)

The over-all reaction is:

$$Fe + 2H^{+} = Fe^{++} + H_2$$

In neutral or alkaline waters the anode reaction is the same, but the cathode reaction is

$$H_2O + 1/2\ O_2 + 2e = 2OH^{-}$$

and the over-all reaction is:

$$Fe + H_2O + 1/2\ O_2 = Fe(OH)_2$$

The quantity of current which passes through the cell is directly proportional to the amount of metal that corrodes. For example, 1 amp./yr. equals about 20 lb. of steel.

If the hydrogen stays on the cathode and forms an insulating blanket, polarization results. This is shown schematically in Figure 3. Polarization interferes with current flow, so corrosion is decreased or stopped. Oxygen, which is present in most commercial waters, combines with the hydrogen-insulating blanket to form water, thus removing the hydrogen film (Figure 4). Current flows and corrosion proceeds. This is depolarization or cathodic depolarization because it occurs at the cathode. For this reason boiler water is often deaerated or sulfites or hydrazine are added to tie up the oxygen. In connection with Figure 4, 1 molecule of oxygen removes 2 hydrogen molecules.

Side reactions or other cathodic reactions can occur in this system and others, but the basic requirements are the same.

Figure 5 summarizes the requirements and can be considered as a basic diagram for corrosion of metals. Anything that upsets this scheme might be useful for stopping, minimizing, or combatting corrosion. For example, polarization, as shown in Figure 3, stops attack. Many inhibitors are effective because they function as polarizers.

Different metals have different reactivities or tendencies to corrode. The familiar electromotive force series lists elements in the order of decreasing reactivity. However, the e.m.f. series is a poor guide for predicting corrosion behavior of metals and alloys in commercial environments. For example, chromium is above iron in the series so the addition of chromium to iron should decrease the corrosion resistance of iron. Actually this mixture results in the stainless steels whose main reason for existence is good corrosion resistance. This increase in nobility or corrosion resistance is due to *passivity* which can be simply defined as "a condition that causes a metal not to corrode when it should."

Passivity is usually due to surface films which act as barriers between the metal and its environment. On stainless steels the film consists of adsorbed gases or oxides. Aluminum is a reactive metal but it is widely used for corrosion applications because of protection by a stable aluminum oxide film. Lead resists sulfuric acid because of the formation of a lead sulfate barrier.

In addition to wet corrosion, most of all other corrosion can be classified as *dry* corrosion or attack when a liquid phase is not present. In most cases this involves high temperatures and, for this reason, is commonly called high-temperature oxidation. This can be described as chemical reaction between a metal or alloy with oxygen, nitrogen, sulfur, or halogens.

Except for the noble or precious metals whose oxides decompose at high temperatures, the successful performance of metals and alloys depends upon the formation of protective oxides or scales. If the rate of scale or oxide formation is linear with time, the material is generally not considered resistant. If the rate of metal consumption or oxide formation decreases with time, a protective scale is forming. In general, the scale must be adherent, continuous, and nonporous for good resistance to high-temperature oxidation.

Additions of chromium, aluminum, and/or silicon to steel (and other metals) results in improved resistance to high-temperature oxidation.

Eight Forms of Corrosion

Corrosion may be classified in the eight forms in which it manifests itself. The basis for this classification is the appearance of the corroded metal. Some of these forms are unique, but all are interrelated. Much information can often be obtained by visual observation of the failed part or equipment. This classification is arbitrary, but it covers practically all corrosion failures and problems. The eight forms are as follows:

1. uniform corrosion
2. galvanic or two-metal corrosion
3. concentration cell corrosion
4. pitting
5. intergranular corrosion
6. stress corrosion
7. dezincification
8. erosion-corrosion.

Uniform corrosion, or over-all general attack, occurs when anodic and cathodic areas keep shifting, and corrosion takes place more or less uniformly over the entire exposed surface. The metal becomes thinner and eventually fails like the "one hoss shay." This form of corrosion accounts for most of the destruction of metals on a tonnage basis. From the technical standpoint, however, uniform attack causes the least concern largely because service life can often be quite accurately estimated on the basis of relatively simple corrosion tests. It is the localized form of corrosion that often results in an unexpected failure.

Galvanic, or two-metal corrosion, occurs when two dissimilar metals are in contact, or otherwise connected electrically, and exposed to a corrosive electrolyte. Corrosion of the less resistant metal is increased and corrosion of the more corrosion-resistant metal is decreased. All of the former usually becomes the anode, and the latter the cathode. Current flows here similar to the situation shown in Figure 5. The driving force for the current is the potential generated by the electrodes. This, of course, is the principle of the so-called dry battery.

Table 1 shows a practical galvanic series for metals and alloys exposed to actual sea water. The farther apart two metals are in this series the greater the potential when they are coupled. The material higher in the series becomes anodic to one below it. Magnesium and copper would form a bad galvanic couple as far as corrosion is concerned. In many cases, the accelerated attack occurs on the anodic metal near the junction with the cathode. The effect spreads farther in a linear direction as the conductivity of the environment increases.

An important effect that is often overlooked, and rapid failures result, is the area effect, or the ratio of cathodic area to anodic area. A large cathode and small anode accelerate further the attack on the anode. A metal by itself in a given environment may corrode at X mils per year; the rate may be 10X when coupled to a more noble metal; but it may be 1,000X when the area ratio is large. For example, steel rivets in copper or Monel plates fail rapidly in sea water because of the unfavorable area effect.

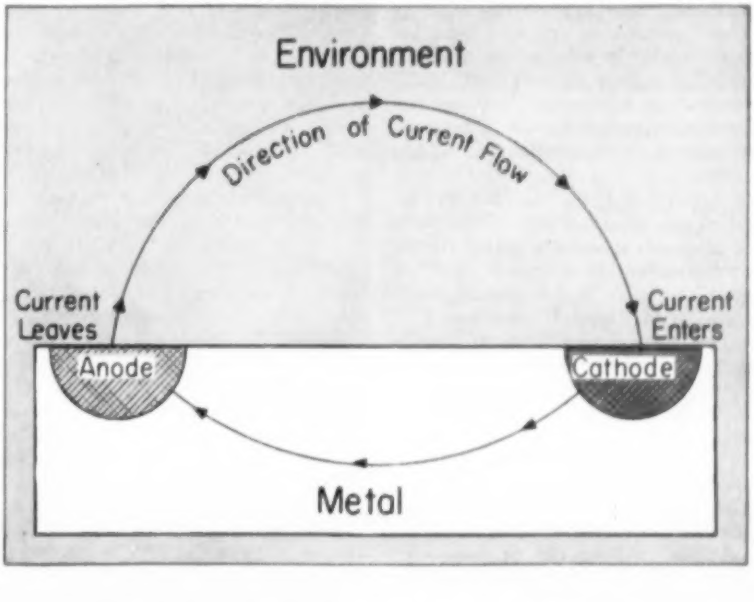
Violation of these simple fundamentals often results in costly failures.

For example, a plant installed several hundred large tanks in a major expansion program. Most of the older tanks were made of ordinary steel and completely coated on the inside with a baked phenolic paint. The solutions handled were only mildly corrosive to steel, but contamination of the product was a major consideration. The coating on the floor was often damaged also because of mechanical abuse, and some maintenance was required. To overcome this situation, the bottoms of the new tanks were made of steel clad with 18-8 stainless steel. The tops and sides were of steel, with the sides welded to the stainless clad bottoms (Figure 6). The steel was coated with the same phenolic paint, with the coating covering only a small portion of the stainless steel below the weld.

A few months after start-up of the new plant the tanks started failing because of perforation of the side walls. Most of the holes were located within a 2-in. band above the weld shown in Figure 3. Some of the all-steel tanks had given essentially trouble-free life for periods as long as 10 to 20 years as far as side wall corrosion was concerned.

In general, all paint coatings are

Fig. 5. Basic diagram showing requirements for the corrosion of metals by electrolytes.



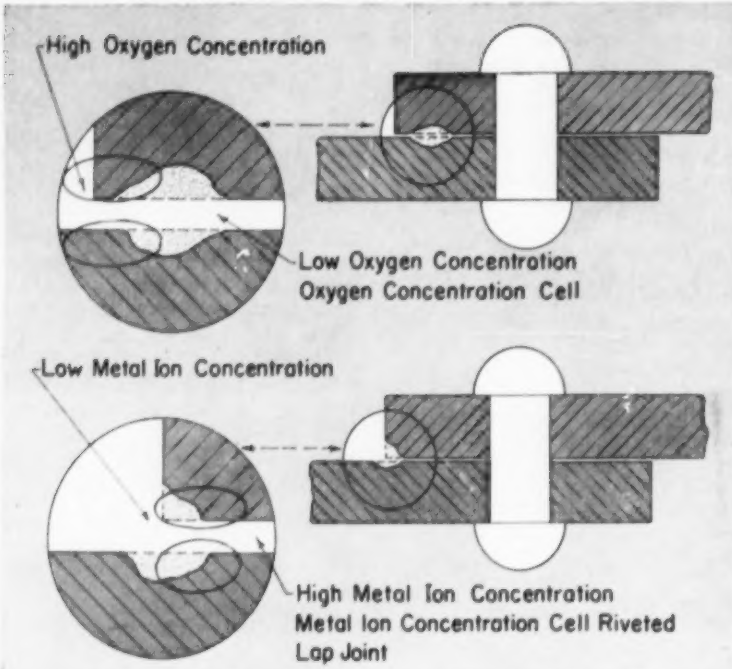


Fig. 7. Typical examples of concentration cell corrosion.

permeable and contain some defects or holidays. For example, this baked phenolic coating would fail in double-distilled water service. The reason for the failure of the new tanks is obvious. A small anode would develop on the steel. This area is in good electrical contact (through the welds) with the large stainless steel bottom surface. In other words, the area ratio of cathode to anode was almost infinitely large!

Too many design engineers seem to take great delight in making parts of as many different metals and alloys as possible. This results in many costly failures that could have been easily avoided.

Concentration cell corrosion occurs when anodes and cathodes form because of differences in the environment. For example, a potential difference can be measured between two identical copper electrodes immersed in different concentrations of hydrochloric acid. The cells, formed because of differences in the environment, are called concentration cells. This form of corrosion is also designated crevice corrosion, gasket corrosion, and deposit corrosion, and is usually associated with stagnant conditions.

The most common forms of concentration cells are oxygen cells and ion cells as shown in Figure 7.

Pitting is readily recognized because of pits or holes. This is one of the most vicious forms of corrosion and one of the hardest to predict. The anodic area remains stationary and corrosion progresses inwardly on one spot. Pitting can be considered as the intermediate situation between no corrosion (complete passivity) and uniform corrosion (entirely active) in that the surface breaks down and corrodes only in relatively small areas.

Pitting often starts because of concentration cell effects such as under a permeable deposit. The environment under the deposit becomes exhausted of oxygen, or increases in ion concentration; whereas, the surrounding metal away from the deposit is exposed to essentially a constant concentration of oxygen or ions. The rate of penetration often accelerates because the pit acts as a crevice and thereby increases the concentration cell effect. An unfavorable ratio of cathode to anode also exists. This is one reason why the stainless steels often show severe pitting in some environments with most of the surface showing no attack.

Intergranular corrosion consists of localized attack at the grain boundaries of a metal or alloy. In some cases, complete disintegration of the metal results even though a relatively small portion of the total weight is dissolved. All metals and alloys usually show grain boundaries to be anodic to the grains. This is the basis for etching specimens in metallographic studies. Stainless steels are particularly notorious from the standpoint of intergranular corrosion.

Stress corrosion could be defined in a general way as the acceleration of corrosion by stress. In some cases, more or less over-all corrosion is increased because of stresses in the metal. Stress corrosion is more generally interpreted as the type of attack that causes cracking, and it is this form of failure that is under discussion here.

In most cases, the magnitude of the stresses required to cause stress corrosion is high. These stresses could be due to applied loads or to residual stresses, although failures because of the former are relatively rare since most structures are overdesigned. The most common of the residual stresses that cause stress corrosion are those resulting from cold working or cold forming and also the "locked-in" stresses resulting from welding. In a few cases, plant failures have occurred because of severe thermal gradients in the metal, which cause high stresses. Tensile stresses are required for cracking.

Stress corrosion usually occurs when over-all or uniform corrosion is low and often negligible. It is somewhat similar to pitting in this respect in that most of the metal is passive but active sites develop. The presence of stress often accelerates this localized attack. A crack is initiated and propagates to failure. Two of the earliest

Table 1.—Galvanic Series—Sea Water

Magnesium and magnesium alloys*
Zinc
2S Al (comm. pure)
Cadmium
24 ST Al (4.5% Cu, 1.5% Mg, 0.6% Mn)
Steel or iron
Cast iron
13%Cr iron (active)
Ni-Resist (high Ni cast iron)
18-8 (active)
18-8-Mo (active)
Lead-tin solders
Lead
Tin
Nickel (active)
Inconel (active) (80% Ni, 13% Cr, 7% Fe)
Hastelloy B (60% Ni, 30% Mo, 6% Fe, 1% Mn)
Chlorimet 2 (66% Ni, 32% Mo, 1% Fe)
Brasses (Cu-Zn)
Copper
Bronzes (Cu-Sn)
Cupro-nickels (60-90% Cu, 40-10% Ni)
Monel (70% Ni, 30% Cu)
Silver solder
Nickel (passive)
Inconel (passive)
Chromium steel (passive) (11 to 30% Cr)
18-8 (passive)
18-8 Mo (passive)
Hastelloy C (62% Ni, 17% Cr, 15% Mo)
Chlorimet 3 (62% Ni, 18% Cr, 18% Mo)
Silver
Titanium
Graphite
Gold
Platinum†

* Anodic end
† Cathodic end

and classic examples of stress corrosion are the "season cracking" of brass cartridge cases and the "caustic embrittlement" of riveted steel locomotive steam boilers. Ammunition became worthless during the wet seasons. Boilers exploded because of cracks starting near the rivets or stressed areas.

Statements have been made to the effect that all metals and alloys could be made to crack under selected conditions of stress and corrosion. Fortunately, stress corrosion happens much less frequently than other forms of corrosion but cracking failures are often serious and unexpected. Table 2 lists a number of metals and alloys and the environments in which stress corrosion may occur. This does not mean that failure would always develop in these combinations, but one should be aware of the possibilities. For example, nickel is widely used in caustic services, and cracking is difficult to develop unless severely cold-worked metal is used. On the other hand, brass cracks readily in ammonia, and "as-welded" steel will fail quite readily in strong sodium hydroxide at elevated temperatures. Figure 8 shows the relation between temperatures and concentration of caustic on the cracking of as-welded steel. These data are based on actual service performance.

There are two schools of thought with regard to the mechanism of stress corrosion. One states that the role of corrosion is merely to form a stress-raiser (pit or trench) and cracking then propagates mechanically. The other claims that corrosion and stress must act simultaneously for crack propagation. The work of Priest, Beck, and Fontana (2) shows the latter to be correct. Application of cathodic protection to stop corrosion stopped the crack—cracking started again when cathodic protection was removed.

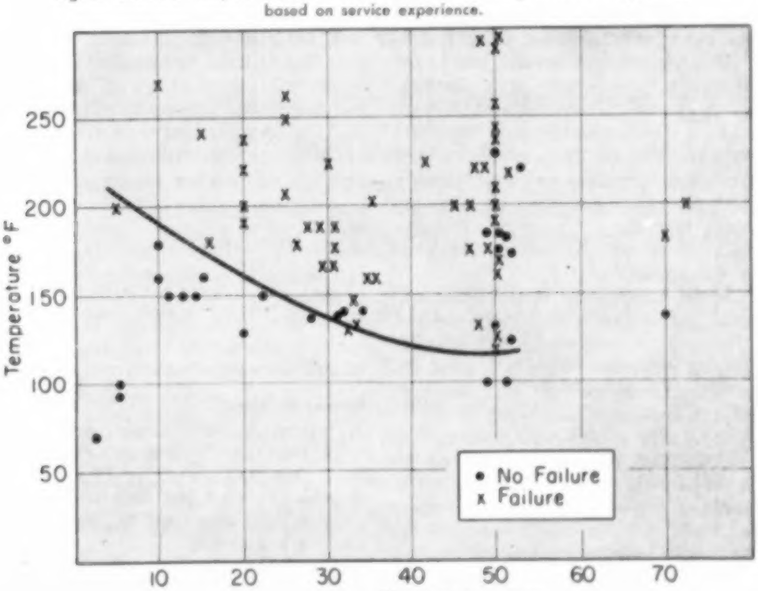
Failure is called corrosion-fatigue when cyclic stresses are involved.

The phenomenon of *dezincification* was first observed on brasses. The zinc is selectively leached out of the alloy leaving a brittle, weak, porous mass consisting predominantly of copper plus copper oxides. The obvious mechanism is solution or corrosion of the brass; then the zinc stays in solution, and the copper plates back on. Dezincification can be readily observed because the attacked areas show the color of copper as compared to the yellow brass. Brasses with 15% or less zinc are practically immune, and additions of tin, arsenic, phosphorus, and antimony increase the resistance of brasses to dezincification. Dezincification can occur uniformly, or as the plug type, or attack in spots.

The selective removal of one of the constituents of any alloy falls into the category described here. The so-called graphitization of cast iron is a misnomer. What actually occurs is the removal or corrosion of iron leaving the graphite network. Selective removal of cobalt in high-cobalt alloys, and silicon in copper-silicon alloys have been observed.

Erosion-corrosion is a combination of corrosion and mechanical wear ef-

Fig. 8. Effects of temperature and concentration on cracking in sodium hydroxide based on service experience.



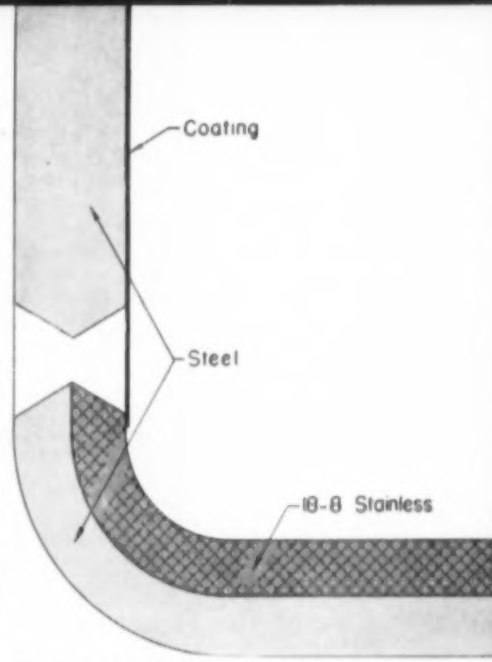


Fig. 6. Detail of welded steel—stainless clad steel tank construction.

Table 2.—Environments That May Cause Stress Corrosion of Metals and Alloys

Material	Environment
Aluminum alloys	$NaCl-H_2O_2$ solutions NaCl solutions Sea water Air, water vapor
Copper alloys	Ammonia vapors and solutions Amines Water, water vapor
Gold alloys	$FeCl_3$ solutions Acetic acid—salt solutions
Inconel	Caustic soda solutions
Lead	Lead acetate solutions
Magnesium alloys	$NaCl-K_2CrO_4$ solutions Rural and coastal atmospheres Distilled water
Monel	Fused caustic soda Hydrofluoric acid Hydrofluosilicic acid
Nickel	Fused caustic soda
Ordinary steels	NaOH solutions $NaOH-Na_2SiO_3$ solutions Calcium, ammonium, and sodium nitrate solutions Mixed acids (H_2SO_4-HNO_3) HCN solutions Acidic H_2S solutions Sea water Molten Na-Pb alloys
Stainless steels	Acid chloride solutions such as $MgCl_2$ and $BaCl_2$ $NaCl-H_2O_2$ solutions Sea water H_2S $NaOH-H_2S$ solutions
Titanium	Red fuming nitric acid

fects. Many metals and alloys depend upon surface films or corrosion products for corrosion resistance. If these surface layers are removed, active and rapid corrosion occurs. Erosion-corrosion is often encountered under conditions of high velocity, turbulence, impingement, and solids in suspension. Valves, pumps, elbows, centrifugals, agitators, and heat exchange tubes often fail because of erosion-corrosion.

Cavitation may be considered as one form of erosion-corrosion. Roughened surfaces or deep craters are often found on the trailing faces of ship propellers and pump impellers. This is cavitation and is largely due to the mechanical effect or pounding caused by the formation and collapse of air or vapor bubbles in the liquid on the metal surface.

Another type of erosion-corrosion is fretting corrosion. It is the attack that occurs at contact areas between metals under load and subject to vibration and actual slip at these surfaces. It is sometimes called chafing corrosion, friction oxidation, and false Brinelling. The last name is used because the attacked areas often look like mechanical indentations. The corrosion product on steel is usually a ferric oxide debris. Two proposed mechanisms involve tearing away of metal particles because of seizing or galling and then oxidation of these particles, or oxidation first and then wearing away of the oxides.

Liquid Metal Corrosion

The use of atomic energy for commercial power has increased interest in liquid metals such as rhodium, lead, and lithium, as heat-transfer media.

In addition to the usual forms of corrosion, another important factor enters the picture. This is mass transfer or the solution of the equipment in a hot zone and deposition of this metal or alloy in a colder area. This is due to marked change in solubility of one metal in another with change in temperature. In addition, a more careful selection of materials of construction must be made because equipment is not as readily accessible for repair as in more conventional systems.

Corrosion Testing

Corrosion testing is conducted to evaluate or select a metal or alloy for a specific environment or definite application, to evaluate a given material to determine environments where it is suitable or attacked, for controlling corrosion resistance of a material or corrosiveness of an environment, or for corrosion research purposes. These tests include laboratory, pilot plant, large-scale plant, or field tests.

The most important point in corrosion testing is to duplicate as closely as possible the actual conditions to be encountered. Factors such as temperature, concentration, velocity, aeration, time, galvanic effects, stress, and intermittent or continuous operation must be considered. Chemical and metallurgical history of the specimens must be known and the specimens identified. A clean metal surface is preferred.

Most corrosion tests involve determination of loss in weight of the specimen and conversion to a rate of linear penetration for prediction of life expectancy. An expression for corrosion rates that is widely used by engineers is "mils per year," and its formula is as follows:

$$\text{mils per year} = \frac{534\,W}{D\,A\,T}$$

W = weight loss, mg.
D = density, g./cc.
A = area, sq.in.
T = time, hr.

Methods for Combatting Corrosion

Many corrosion problems can be solved by more than one method or means. Sometimes a combination is used. In any case, the most economical solution to the problem is usually adopted. Methods for combatting corrosion are arbitrarily classified into eight general categories that cover essentially all corrosion problems.

Alloying, or better corrosion resistance, involves using materials with better resistance to corrosion. If steel corrodes, copper, stainless steel, or high-silicon iron may do the job. Proper heat treatment for optimum corrosion resistance is also in this classification.

Cathodic protection involves making the structure to be protected the cathode of a cell. This can be done by two general methods: namely, use of sacrificial anodes or impressed currents. The most widely known sacrificial anode system is galvanized steel where the zinc coating is the anode and corrodes preferentially, thereby protecting the steel. Zinc and magnesium anodes are also widely used. The important point is to have direct current entering the entire surface of the structure to be protected. Impressed currents involve passing a direct current from an external source through an anode, through the corrosive environment, and then to the structure. In this case, a corrosion-resistant or "permanent" anode is needed. Carbon and 14.5% silicon iron (Duriron) are used for impressed current anodes. Underground pipe lines, water tanks, seagoing vessels, and piers are all structures using cathodic protection.

Metallic and inorganic coatings are typified by nickel, chromium, and tin electroplates, and glass and enamels. The principle here is to install a barrier to separate the metal from the environment.

Organic coatings involve paint-type materials, which act as a barrier. Proper metal surface preparation, such as sand-blasting, is the most important factor, followed by a proper primer for good adhesion and compatibility with overcoats, and then by good top coats themselves. Use of an expensive paint does not guarantee that good protection will obtain.

Metal purification is not often utilized, but it does solve some problems. High-purity aluminum, which is available at reasonable cost, is a good example. Contamination and catalytic effects are sometimes involved.

Alteration of the environment often concerns addition or removal of an ingredient in the environment. Deaeration is an example of the former and inhibitors of the latter. An inhibitor is anything added to an environment to decrease corrosion. In many cases, reduction of temperature or concentration, without substantially affecting the process, solves a corrosion problem, or permits the use of less expensive materials such as steel.

Nonmetallic materials involve integral or monolithic construction or thick coverings such as sheet linings. These materials can be classed into five general types: (a) carbon and graphite; (b) ceramics, such as stoneware, porcelain, fused silica, glass, brick, mortars, and cement; (c) plastics, such as phenolics, vinyls, polyethylenes, acrylics, epoxies, styrenes, nylon, silicones, and fluorinated polymers; (d) natural and synthetic rubbers; and (e) wood.

Design involves the shape of a structure. Equipment life can be prolonged or corrosion costs reduced through the use of bottom outlets designed to drain completely, readily replaceable or interchangeable parts, standard lengths of tubing, increased thickness in more vulnerable areas, designing to prevent crevices or stagnant areas, and the use of butt-welded instead of riveted joints.

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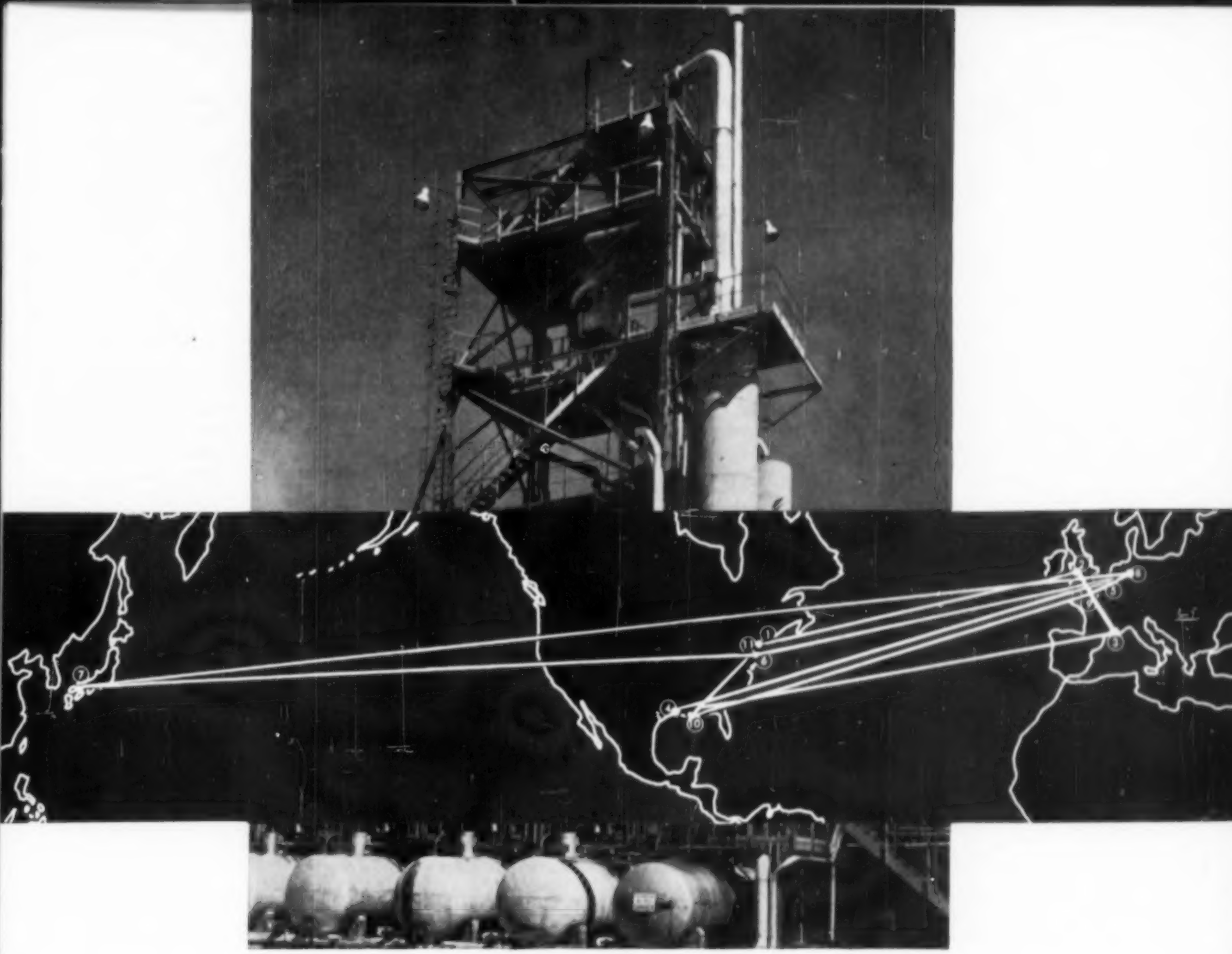

International Collaboration in the Chemical Industry

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Too little is generally known of the scope of existing process licensing agreements and technical cooperation between private chemical and engineering firms in the United States and their opposite numbers abroad. The author presents here a panoramic view of an extremely complex network of typical interrelationships.

INTERNATIONAL TRAVEL OF SD'S ETHYLENE OXIDE PROCESS
(See map above)

1) Scientific Design Co., Inc., **New York City** (laboratory investigation and development). 2) Petrocarbon, Ltd. and Petrochemicals, Ltd., **England** (pilot plant). 3) Naphtachimie, **Lavera, France** (first commercial plant). 4) Allied Chemical & Dye, **Orange, Texas.** 5) Societe Chimique des Derives du Petrole, **Antwerp, Belgium.** 6) General Aniline & Film Corp., **Linden, New Jersey.** 7) Mitsui Petrochemical Industries, Ltd., **Iwakuni City, Japan.** 8) Farbenfabriken Bayer, **Leverkusen, Germany.** 9) Marles-Kuhlmann, **Le Havre, France.** 10) Jefferson Chemicals Co., **Port Neches, Texas.** 11) SD Catalyst Manufacturing Plant, **New Jersey.**

Any observant world traveler today cannot escape a realization of the vast problems which confront the United States in its efforts to encourage the growth of freedom and independence in Asia, South America, and Africa, as well as in Europe.

In commenting on the complexity of these problems, Bober (*2*) focused attention on the difference between the fundamental trends of history and the more spectacular but evanescent antics of human actors on the political stage. He cites two vast impersonal forces: namely, the incredibly rapid increase in world population, and the advance of the machine age and modern technology. He illustrates the first by showing that "every 25 years we are adding an additional billion mouths to feed . . . The impact of such a powerful force will compel even the most advanced countries to industrialize far more rapidly." On the second point it can be stated categorically that the rate of advance of technology should indeed be accelerated because science must not only cope with the

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growing population problem, but also thanks to nationalistic feeling it is expected to raise the standard of living of all people simultaneously. In summarizing the difficulties which lie ahead for the United States, Bober concludes that this country must

> . . . reject the idea that we can become and remain the arbiters of everyone else's destiny . . . We cannot hope to dictate the path of development for the remaining 94% [of the world's population] with their totally different history and traditions . . . It is, therefore, up to the United States to prove, by precept, example, and assistance to other nations, that maximum material achievement can go hand in hand with the constitutionally limited and democratic state with its priceless human freedoms.

The Committee for Economic Development has recently treated this same theme *(5)*. It recommends that private channels be the major instrument for American aid to growth abroad, but it asserts that such growth will not occur unless the fundamental effort comes from the people of other countries themselves. To aid the exploitation of each nation's resources, and especially in those cases where resources are meager, the committee cites the necessity for technical and management collaboration between the United States and other countries, "through example, experience, contact, and training." It also stresses that American private businesses, including private management consultants, should be encouraged in this "cooperative effort at development," thereby also gaining the important by-product of "increasing the contacts of enterprise in developing countries with U. S. enterprise."

Chemical Industry Leads in Promoting Private Contacts

It is the purpose of this article, based in part on personal experiences, to cite illustrations of private industry's substantial efforts in such cooperation since the end of World War II, thereby suggesting that such private cooperative efforts between American and foreign entities are not as rare as might be construed from these articles. The chemical process industries are logical ones for particular examination for the following reasons:

- **They are basic to the world's economic growth, for their manufactures encompass fertilizers and insecticides for increasing agricultural production, drugs, fibers, dyestuffs, rubbers, plastics, and the widest group of products needed by man.**
- **They exist in some form in many countries, and usually as private industries.**
- **They are mature, having been long established in most countries.**
- **They can contribute, as well as receive, new ideas, practices, and inventions in many countries.**

The last point is particularly interesting. It has become clear to all who venture abroad on scientific or business missions that today's powerful nationalism makes foreign companies and their personnel quite touchy in their dealings with Americans; they expect and deserve to be treated as equals. Maintaining such a spirit can be difficult in certain industries, such as petroleum, where the vast size and economic development of the United States have brought about the most rapid evolution of geophysical methods, refining techniques, high octane blending agents, and other petroleum additiyes. The petroleum industry abroad indeed has a "made in America" look. The chemical process industries, on the other hand, have no such obstacles, and inventions have come from many quarters *(4)*.

Collaborative development of new processes and plant designs in conjunction with foreign companies is one of the fruits of such binational effort by process industries' member organizations. This is definitely a bilateral or multilateral effort, whereby processes discovered in the United States can be brought to commercial stature in pilot plants abroad, and foreign processes can be perfected in the United States. Such activities were preceded by earlier but different cooperative efforts, some of which are described below.

Joint Manufacturing Efforts

Many American chemical process companies, including Dow, Union Carbide, Monsanto, Pfizer, Hercules, Goodrich, Atlas, Oronite, and others, have for many years been engaged in the establishment of joint companies with foreign interests in such countries as the United Kingdom, France, West Germany, Australia, Italy, Japan, Brazil, and India. More recently, foreign companies have participated in the establishment of joint ventures in the United States, bringing know-how and capital here.

Examples are Mobay (consisting of Monsanto and Germany's largest company, Farbenfabriken Bayer), producers of isocyanates; a combine of Hercules and England's ICI to produce methacrylate plastics in Missouri; a titanium-producing group in Tennessee involving the Crane Company and a subsidiary of France's Pechiney, and others.

A somewhat novel variant of this pattern is the joint company established by the W. R. Grace Company of the U.S. and Germany's Farbwerke Hoechst to manufacture insecticides and chemicals in Brazil.

These ventures have aided in the growth of mutual understanding between the participants and their countries, and in these by-product results, have probably been more successful than would have been the case if the investment in one country had been entirely by a foreign company with no local participation. In fact, there are today fewer instances where chemical process companies operate on foreign soil essentially through wholly owned subsidiaries of the parent.

International Licensing by Manufacturers

Also well known in the private area of exchange of technology are many licensing arrangements whereby American chemical companies license foreign companies to manufacture under their patents, and/or know-how, usually for payment of royalties. Conversely, American firms secure licenses to operate plants under rights owned by foreign companies.

The Ziegler low-pressure and ICI high-pressure polyethylene processes have been widely licensed in the U.S. to such firms as Du Pont, Carbide, Dow, Monsanto, Hercules, Spencer, Goodrich, National Petrochemicals, etc. The Hercules (U.S.)—Distillers Company (British), joint development in making phenol from cumene, was licensed to Oronite in the U.S., British American-Shawinigan in Canada, Progil in France, Phenolchemie in Germany, Mitsui in Japan, Societe Chimique Des Derives du Petrole in Belgium, etc. The Badische Anilin process for making acetylene from natural gas was licensed to Monsanto, American Cyanamid, and Rohm and Haas in America. The Calico Printers Association (Britain) discovered a polyester fiber; du Pont bought the U.S. patent outright and now makes the fiber (Dacron) in the U.S. ICI was granted an exclusive license for the rest of the world and, along with its affiliate CIL, makes it as Terylene in England and Canada.

Reciprocally, silicone technology (developed in the U.S.) has been licensed abroad by Dow Corning and General Electric. In the same category of U.S. licensing abroad, Union Carbide and Phillips Petroleum will aid the Ente Nazionale Idrocarburi, Italy, in making synthetic rubber from natural gas. In an interesting reversal of the polyethylene licensing flow into the U.S., Union Carbide has recently announced a license of a polyethylene process to Italy's Societa Edison (with capital participation as well). Koppers has licensed two firms in France, one in Italy, and one in Brazil, to make styrene and polystyrene. Phillips Petroleum Company has licensed a number of companies abroad to make low-pressure polyethylene by still another type of process.

In this area of licensing, while contacts are not usually as intimate or enduring as in the case of joint manufacture, there are also rewarding opportunities for private, personal, and corporate interactions.

Licensing by Engineering Companies in Petroleum Hydrocarbon Field

Despite these and other progressive examples, many such licensing and participation arrangements are limited in scope and extent. Seldom is a major operating chemical process company, particularly in the organic chemical field, anxious to license many companies in other countries. There are sound commercial reasons for these restrictions.

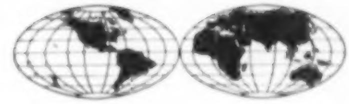
- Markets are limited for chemical products and are frequently costly to develop. Tariffs are by no means impenetrable; also, the American antitrust laws operate to limit restrictions on geographic sales of products. Hence, a chemical manufacturer will be reluctant to risk a loss of some of his own markets by licensing a potential competitor, even in another country.

- Royalty income is frequently heavily taxed, particularly by some foreign countries, and hence their nationals are unwilling to sell valuable rights for a small net return. Sometimes such companies will exchange process rights or know-how, but it is rare that the two partners in such an arrangement will have packages of equal value that interest each other.

- Frequently, restrictions on currency transfer or on remission of profits from an operating company abroad are severe enough to limit these activities (*1, 6*).

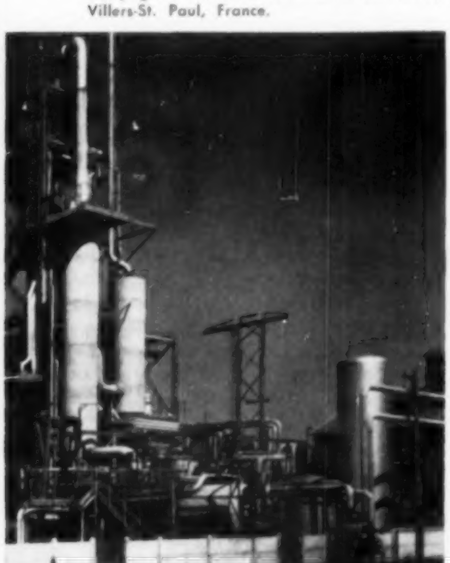
- In many processes, secret know-how is an important ingredient in the total value of the entity; it is natural to wish to conserve secrecy by being ultraconservative in licensing policies.

The last point is especially true of the chemical process industries. In contrast, wide technological exchanges have occurred in the petroleum, electronic, and mechanical industries, among others, for various historical reasons. In order to aid these exchanges, there appeared some thirty-odd years ago in the United States, for the first time anywhere, the research-minded engineering and process development firm, dedicated to the petroleum industry. While many oil companies devoted their financial and human resources to the search for crude oil and the establishment of retail marketing outlets, these engineering organizations developed new refining processes that could be widely used.

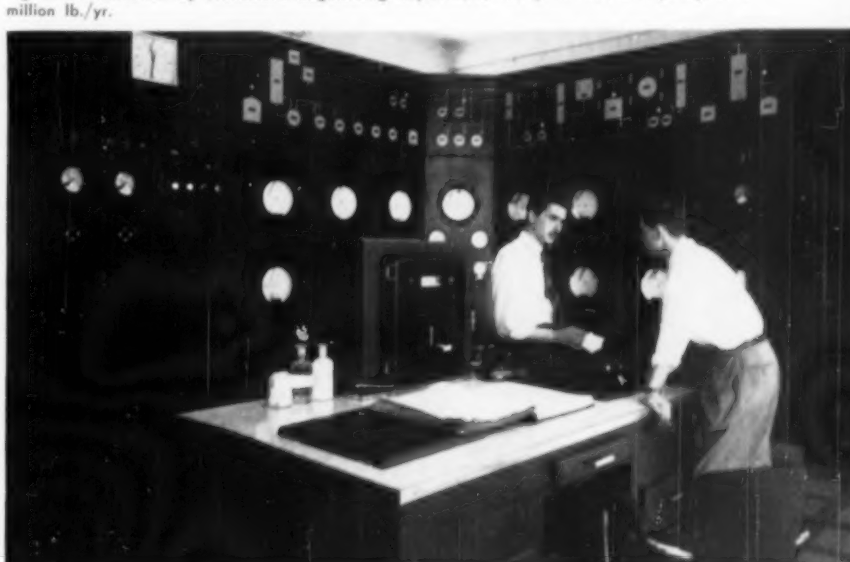


The chemical engineer was a relatively scarce specialist, thirty years ago. Because demand for him was growing rapidly as a consequence of the huge-scale continuous processing required in refining petroleum, the chemical engineer, therefore, tended to concentrate in the manpower pools of engineering development firms which could thereby furnish needed technical services economically and promptly to many oil companies.

The activities of such companies have now spread into related fields, such as petroleum-derived hydrocarbon production. They have licensed foreign and domestic manufacturers to produce key intermediates for further processing. An illustration is found in the field of ethylene manufacture. The technology of making pure ethylene is more difficult than might be supposed, and before the war only a few companies knew the secret. After the war, many companies in the U. S. and abroad felt the urgent need to produce ethylene derivatives for their growing markets. If each one had had to pause for several years to develop ethylene processes utilizing scarce technical manpower for the purpose, his whole program for making ethylene derivatives might have been set back five to ten years, with serious consequences to his own and the



Reactor and column structure of maleic anhydride plant recently placed on stream by Compagnie Francaise des Matieres Colorantes, Villers-St. Paul, France.



Control room of the Francolor maleic anhydride plant. Superintendent Jean Ciquier, left, Robert W. Simon, Scientific Design, right. Designed and engineered by SD and with additional engineering and construction by Francolor's engineering department, the plant has a capacity of 3 million lb./yr.

national economies. Thus, it was fortunate that there were American and European development engineering firms which were able to help spread technology and contacts internationally while pursuing their natural business policy of licensing to a broad extent.

For example, Stone & Webster, Kellogg, and Lummus have licensed their respective naphtha and light hydrocarbon cracking and separation processes to such well-known chemical companies as ICI, British Hydrocarbon Chemical Company, Montecatini, Naphtachimie, Gulf Oil, Petroleum Chemicals, Inc., Standard Oil Co. (N.J.), and others. In the same area, the French Air Liquide and the German Linde companies have furnished technological aid in Belgium, Germany, and elsewhere.

In related fields, U.O.P. has made its Catalytic Reforming Process for aromatic production available to foreign companies, such as Mitsui in Japan, and to many in the U.S. The manufacture of butadiene from butane by the Houdry Process Company techniques, first applied during the war in the U.S., has been exported, for example, to Chemische Werke Huls.

Licensing by Engineering Companies Specializing in the Chemical Field

Less well known than the above instances have been cases of similar research licensing, and design activities by firms specializing in the design and construction of chemical plants. This situation is caused by the aforementioned secrecy prevailing in the chemical process industries, the lack of sufficient volume of business to justify research in the chemical field by engineering firms, and the high cost of such research. A limited number of examples of such individual activities in chemicals may, however, be found, since it is quite possible to overcome such difficulties. One of the earliest was the Chemical Construction Corporation, specializing in heavy inorganic chemical processes and plant designs. Another of the pioneers in this area has been Scientific Design Company, Inc., which specializes in the development of organic chemical processes and in the engineering design of chemical plants.

A rewarding activity, both financial and professional, of an engineering and research company is the development, and subsequent licensing and design of a newly discovered process to commercial plant status with the collaboration, both technical and financial, of an overseas company. Frequently, an American manufacturing company has participated in the chain of development. It is to be noted that in all cases important contributions were made in the evolution of these processes and in the design of plants by the foreign as well as the American participant, and that these projects were all arranged between private companies. One of the most valuable by-products of such activities is the stimulus given each participant by the process of mutual development and plant design. It is perhaps one of the most intimate relationships which can exist between businessmen and technicians of two countries. Such associations occurred among private American chemical companies during the war, and it was often to the genuine regret of the people involved that these contacts were largely eliminated by the exigencies of postwar competition.

Ethylene Oxide by Direct Oxidation

Development of the Scientific Design ethylene oxide process is a prime example of joint activities. In 1946, studies were begun in its U. S. laboratory for manufacture of ethylene oxide by direct air oxidation, based on Lefort's earlier work in France with a silver catalyst. However, due to the inherent complexity of the process, the design of commercial units needed checking on a pilot-plant scale. SD did not have a pilot plant at that time nor sufficient capital to build one by itself. Fortunately, there was wide interest in such a process, and many companies, both here and abroad, were researching in this same field.

Petrocarbon Ltd. and Petrochemicals Ltd. in England were interested in conducting the pilot-plant phase of the investigation jointly with Scientific Design. The English group was then an independent newcomer to the United Kingdom chemical field, and was not sure that chlorine would always be available to it for supplying the needs of its ethylene oxide plant via the chlorhydrin process, the construction of which was just beginning. The English were willing to finance a pilot plant for the direct oxidation process to assure their future independence of chlorine supplies, but they did not have their own process. The joint operation was mutually attractive, for SD could develop its process for sale and Petrochemicals Ltd. was assured of a preferred position to manufacture by this process, if it desired.

Once perfected, the process was then licensed to Naphtachimie in France, which completed the first commercial plant. Dollar currency required was provided by the E.C.A. of the U. S. At the same time Naphtachimie built facilities for the manufacture of the silver catalyst based on SD patents and know-how.

Both the ethylene oxide plant and the catalyst unit have been operating since 1953. SD has had full access to all operating data since that time in accordance with the license agreement it made with Naphtachimie. Nine more ethylene oxide plants have been or are being designed and engineered in Germany, Belgium, Japan, and the U. S., for companies such as Allied Chemical & Dye Corporation, SCDP, General Aniline & Film, Mitsui, Bayer, Marles-Kuhlmann, Jefferson Chemical, BASF, etc. Most licensees, like Naphtachimie, have agreed to make data from full-scale operation available to other licensees on a reciprocal basis. In this "know-how exchange" members contribute improvements and operating data to one another through SD, which acts as a clearing house. An "exchange" of this nature has many advantages to its members. It provides an orderly channel whereby improvements can be made known and cross-licensed for the benefit of all. The risk of costly patent litigation is much less than might otherwise be expected. In addition to cost, such interferences, oppositions, or litigations tend to engender delays and harassments to those endeavoring to achieve desired productivity.

Each contributor to the know-how exchange increases his chances of improving his own operation roughly by the number of other members, and the danger of obsolescence is greatly decreased. Yet, by suitable secrecy agreements, the legitimate interests of each member of the exchange have been protected, without any limitation of markets or other agreements questionable under the antitrust laws. Much credit must go to the imaginative foresight of the Naphtachimie management who were the first to visualize the potential benefit to themselves of collaborating with future licensees.

One method of communication to be used in the know-how exchange is the periodic meeting. Perhaps once a year representatives of various licensees will meet at one of the plants to discuss technical problems, improvements, and general plant operations. The benefits of such continuing international contacts may be gauged by the enthusiasm which surrounded the 1955 Atoms-for-Peace conference in Geneva, the first of its kind. (In the nuclear field, the necessary secrecy restrictions had operated, prior to 1955, to minimize contact among scientists of other nations.)

SD recently completed a catalyst plant in New Jersey to make silver catalyst for ethylene oxide production. The operating experience of Naphtachimie was helpful in designing this plant. Catalyst in commercial quantities will be available. For licensees distant from New Jersey (such as Mitsui in Japan), who wish to build their own catalyst unit, information in accordance with the know-how exchange agreements is available from SD and Naphtachimie.

Rights Acquired to Hydrocarbon Liquid-phase Oxidation Process

Announcement was made recently by Standard Oil Co. (Indiana) that it had acquired from SD associates a worldwide exclusive rights position in a new hydrocarbon process for the direct air oxidation of raw materials such as xylenes to the corresponding dibasic acids. There is an international flavor attached even to this wholly American process. The first discoveries were made in the U. S. by the SD group. So important did these appear in future potential that France's Pechiney acquired a license at an early phase of the development. Stimulated by this substantial encouragement from abroad, the SD group, in order to speed the development, and to maintain maximum rights for itself (including its participation in a possible manufacturing venture to make terephthalic acid in the U. S.), decided to invest its own funds in a substantial pilot plant in the U. S. Pechiney technicians visited this unit several times. Eventually, Standard Oil Co. (Indiana) acquired the SD group position outright, but SD received the licensing agency outside the U. S., and soon Japan's Mitsui and Maruzen Oil acquired licenses. Certain exchange features are also provided under the various agreements, and stimulating contacts between an American oil company, an engineering company, and foreign operating companies will surely prove worthwhile for all concerned in broadening viewpoints and understanding, and aiding further process developments and improvements in plant design.

A by-product of this activity emerges from the fact that Standard Oil Co. (Indiana) also acquired rights to a pure-cumene process. SD had originally designed such a unit for Barrett's phenol plant; subsequently the process has been licensed to Mitsui, and to British Hydrocarbon Chemicals Co. (British Petroleum Co. and the Distillers Co.), with certain exchange features included.

Evolution of Chlorinated Hydrocarbon Processes

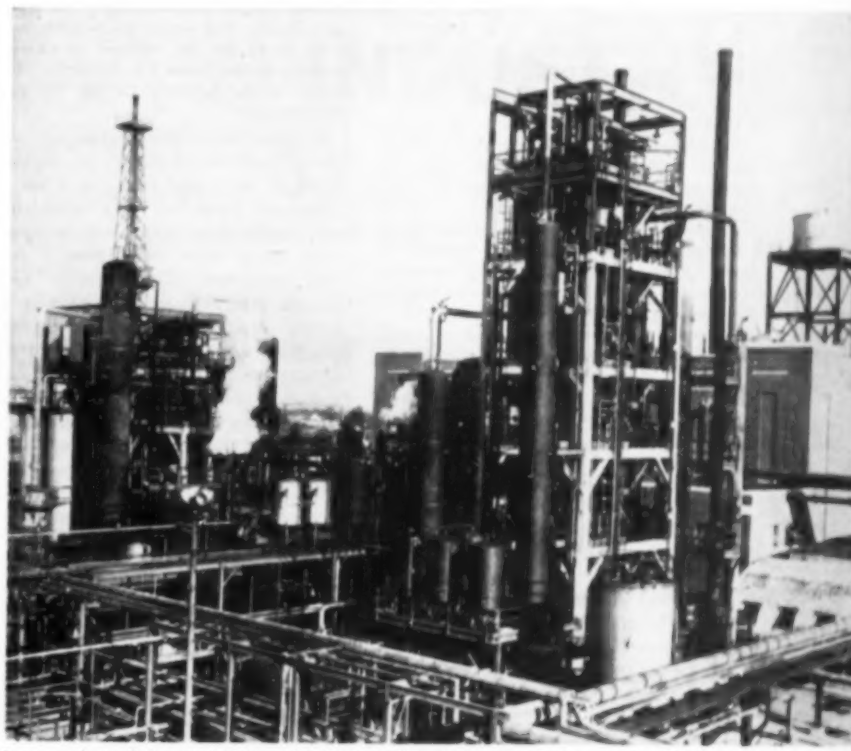
Several years ago, natural gas was discovered in Italy's Po valley. Montecatini, a major chlorine manufacturer, commenced a program of studies to provide for future utilization of such gas.

A pilot plant was built at Novara for chlorination of methane to produce methyl chloride, methylene chloride, chloroform, etc. But even before Montecatini was ready to build a commercial plant, the Solvay Process Division of Allied Chemical & Dye had a commercial requirement for such products. SD designed Solvay's plant, extending the data obtained in the Italian pilot plant to the different U.S. conditions, and providing its own inventions to suit large-scale requirements. This is believed to be the first plant in the U.S. that involved Montecatini activities. In the course of the close relationship that had arisen between SD and Montecatini it became apparent that the pilot plant could be adapted to chlorination of methane for production of perchlorethylene.

However, in probing Pechiney's interest in this route, SD learned that methane was not available at St. Auban, the proposed site, but other light hydrocarbons could be shipped in. Montecatini was asked to test out certain suggestions for use of such other feedstocks and this was successfully done. However, Pechiney required as a by-product anhydrous hydrogen chloride gas, but the water quench then in use at Novara, adequate for the pilot plant purposes, would not readily permit recovery of pure hydrogen chloride. SD proposed that a solution of hydrochloric acid could economically be substituted for the water in Montecatini's pilot plant (3). This proved feasible for recovery of hydrogen chloride gas by stripping from the concentrated solutions. Pechiney's plant could then be fully designed, and has now gone on stream.

Maleic Anhydride Goes Abroad

Scientific exchange has also occurred in the field of maleic anhydride by air oxidation of benzene.



Cumene plant of Barrett Division, Allied Chemical and Dye Corporation, at Frankford, Pa.

Initially, research work was conducted in SD laboratories, then, in a related area with one foreign company on a pilot plant scale. In 1955 some aspects of this work were applied to the Elizabeth, N.J., plant of Reichhold Chemicals, Inc. which had an immediate interest in higher yields and longer catalyst life owing to a rather sudden change in the price relationships between benzene and maleic. The resulting plant-scale tests in the reactors, employing special catalyst, were successful, and Reichhold acquired certain rights in the U.S. Shortly thereafter, a complete plant was designed for Compagnie Francaise des

Matieres Colorantes in France. This plant has recently been placed in successful operation. Here, too, some of the operating experience will be available to others. Because maleic anhydride uses have grown rather slowly, the scale of plant required (as for example in France) is not great. Normally, therefore, the cost of developing a process of this complexity would be prohibitive.

Because an engineering company had been able to develop the process for them, the French company was able to develop more rapidly the internal market for maleic, such as in polyesters, fungicides and alkyds, while still being able to sell it at a low price (unburdened by excessive research costs).

Polyvinyl Chloride by Suspension Polymerization

In 1952 SD was engaged to build a $6 million mono- and polyvinyl chloride plant at Ashtabula, Ohio, for General Tire and Rubber Company.

General Tire was seeking to integrate all its plastic activities back to basic raw materials, for it was already making vinyl finished goods. At that time, the majority of the polyvinyl chloride made in the U.S. was by emulsion or bulk polymerization. General Tire needed a process quickly, but it also wanted an all-purpose polymer, preferably made by the newer suspension polymerization techniques, to provide for future competitiveness. However, it did not of itself possess all the know-how required. In this case arrangements were made with a prominent European firm to exchange ideas as to extrapolation from pilot plant data. Large-scale equipment was made available to help in proving out the best processes and products, which were then modified to fit General Tire's plant.

With this large plant experience, a simplified, smaller, "packaged" polymerization plant was devised by SD which was inexpensive enough to permit users of PVC to make their own all-purpose polymer economically as a captive operation. Such plants have been successfully completed for Borden, Thompson Chemicals Company, the Eleonora Chemical Company (now The Pantasote Company) and Cary Chemicals, Inc., with one other under construction.

Other Published Examples *

- **M. W. Kellogg collaborated with Sherwin-Williams in designing a large pilot plant to develop the fluidized bed process for oxidation of naphthalene to phthalic anhydride; after some years of development, Kellogg is understood to have built a large commercial unit for ICI in England.**
- **Foster-Wheeler adapted Pechiney's semi-commercial urea plant to large-scale application in the U. S. for W. R. Grace and John Deere. Vulcan did much the same with the Inventa process for Standard Oil (Ohio). Chemical Construction worked out a urea process jointly with a Japanese firm and licensed it subsequently to Cyanamid in Canada.**
- **The Texaco-Hydrocarbon Research partial oxidation process for synthesis gas and hydrogen production from natural gas, was first used in the U. S., but was adapted to different conditions by the French firm Kuhlmann, using fuel oil as the feedstock for the first time anywhere.**

By these, and related techniques, the international development of organic chemical processes and plants on a substantial scale has been stimulated and important international relationships have been established. Activity continues along various new lines, such as phthalic anhydride, antibiotics, adipic acid, glycerine, organic amines, diisopropylbenzene derivatives, polystyrene, and many others. The difficult task of making new technologies available for licensing whether originated by a design development company acting alone or in association with others, or as licensing agent, seems to have been solved with adequate protection of legitimate trade secrets of all concerned.

By these means manufacturing companies in many parts of the world have been able to husband their limited technical and financial resources and apply them primarily to the development of products and processes peculiarly suited to their markets and interests, while the intermediates or raw materials process know-how have been found among the assets of engineering development firms. In fact, these developments have followed a pattern previously encountered in the evolution of equipment design, such as pumps, instruments, compressors, etc. No longer do serious process industries companies find it profitable to develop such equipment themselves, but rather, they buy the accumulated know-how of the manufacturer in the form of the piece of equipment in question, and integrate into the special larger whole which the process company uses as its basis for profitable existence. Now, the trend is unmistakably evident that chemical process industries will no longer find it profitable to develop a process (or even design the plant) if it can be bought elsewhere, but instead will integrate it into the larger complex of a raw material situation, a particular location, a particular coincidence of timing, the control of a market, etc., from which complex the profits of the enterprise really flow. And perhaps most important of all, privately employed specialists can learn from each other's point of view, both professionally and culturally, and quietly serve as ambassadors of good-will from their respective countries to their equals among free men everywhere.

* Not based on author's personal experience.

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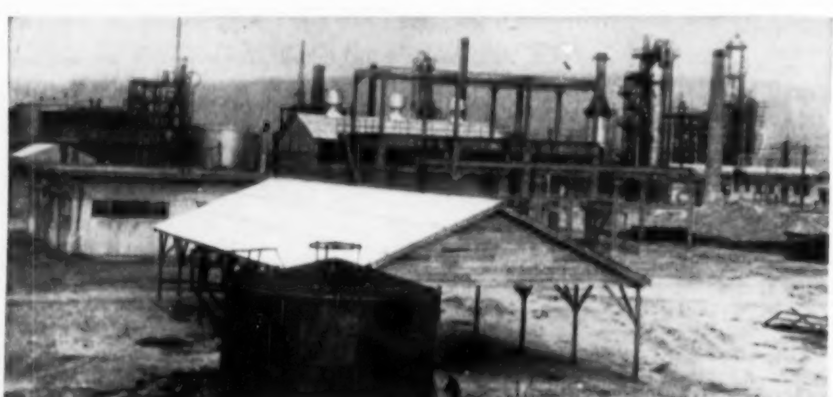

Ethylene oxide plant, designed and engineered by SD, under construction for Mitsui Petrochemical Industries, Ltd., Iwakuni City, Japan.

the interrelationship between SODA ASH and the CHLOR-ALKALI INDUSTRY

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What is the impact of new processes and new use patterns on the traditional stability of the soda ash and chlor-alkali industry? Here is an inside evaluation of present and probable future trends.

A prediction was made in 1952 that there would be no catastrophic surplus of caustic soda or decline in prices, or other insurmountable problems in the marketing of caustic soda for at least another five years and that 1957 would be more a year of decision than 1952. Now 1957 is here and nearly over and caustic soda prices have risen rather than declined, production has increased, markets have been expanded, and caustic soda has continued to be the stalwart servant of industry that it has been for a hundred years.

Table 1.

PRODUCTION (thousand tons)

	Chlorine	Caustic soda
1925	165	507
30	205	700
35	330	761
40	605	1,100
45	1,192	1,864
1946	1,165	1,873
47	1,447	2,134
48	1,621	2,358
49	1,767	2,222
50	2,069	2,487
1951	2,511	3,098
52	2,596	3,011
53	2,796	3,262
54	2,893	3,390
55	3,408	3,907
1956	3,783	4,213
57	3,846	4,138
* 1960	5,000	5,500
* 1965	7,000	7,700

* Estimated.

Source: U. S. Dept. of Commerce.

However, if this is to be the year of decision, what may yet happen? There are numerous factors which will have an important bearing on the situation and which must be resolved before any clear picture can be established. Some of these are:

- future growth and demand for chlorine
- development of technology to produce chlorine economically without producing caustic soda
- market growth potential in end-uses for soda ash
- market growth potential in end-uses for caustic soda
- growth potential in end-uses of products in which either soda ash or caustic soda can be used
- relationship between cost and demand for caustic soda vs. soda ash and the influence on consumer preference when there is a choice between the two.

* M. E. Clark is vice-president (marketing). C. F. Gerlach is sales manager, inorganic chemicals, Michigan Alkali Division.

Chlorine vs. Caustic Soda

Figure 1 shows trend of production growth for caustic soda vs. chlorine. The thinking that went into this representation indicated that the lines in the drawing might reach the crossing point in 1957, that is, the point at which chlorine production would be as great as caustic soda production. While production capacities are near the crossing point, the actual production figures show the lines to be approaching but not quite at an equivalent point as yet (see also Table 1).

Caustic production is based upon electrolytic chlorine production equivalent rates rather than market demand since, if most of this production is to be electrolytic chlorine the caustic soda production will increase stoichiometrically.

As had been expected, chlorine usage in some industries has been slowed down by the development of other more economical processes. For example, most of the new ethylene glycol capacity installed since 1952 does not require chlorine, whereas most of the capacity prior to that time had been a heavy user of chlorine. Also, the increasingly difficult problem of disposing of by-product hydrogen chloride has militated against the use of chlorination processes in some organic reac-

tions. Chlorine, furthermore, is coming in for additional competition in the bleaching of paper from chlorine dioxide and other bleaching processes. It is still a fast-growing industrial chemical, but the previous rate of 12 to 14%/yr. increased consumption has now been reduced somewhat.

These are modifying factors. None can escape the conclusion, however, that chlorine is a faster growing chemical than caustic soda and inasmuch as the production ratio of these two materials by the electrolytic process is a fixed relationship, surpluses of caustic soda will undoubtedly be problems from time to time. All major factors in the chlor-alkali industry are aware of this and are working continuously to effect a solution.

Table 4.—Price Trends, 1930-1957
(dollars per cwt.)

	Chlorine (liquid, tanks)	Caustic soda (50% liquid, tanks)	Soda ash (light, bulk)
1930	$1.50	$2.45	$1.10
31	1.85	2.20	.95
32	1.85	2.10	.95
33	1.85	2.10	.95
34	1.85	2.10	.95
1935	2.10	2.10	.95
36	2.10	2.10	.95
37	2.10	2.10	.95
38	2.10	2.10	.95
39	1.80	2.10	.85
1940	1.80	1.95	.85
41	1.80	1.95	.85
42	1.80	1.95	.85
43	1.80	1.95	.85
44	1.80	1.95	.85
1945	1.80	1.95	.85
46	1.80	2.00	.85
47	2.00	2.25	.95
48	2.40	2.40	1.05
49	2.40	2.40	1.05
1950	2.55	2.55	1.10
51	2.70	2.55	1.10
52	2.70	2.55	1.10
53	2.93	2.55	1.35
54	2.93	2.70	1.35
1955	2.93	2.70	1.45
56	3.05	2.80	1.55
57	3.15	2.90	1.55

Source: U. S. Dept. of Commerce

Chlorine Without Caustic Soda

An often expressed hope of the industry is that methods will be found to produce chlorine without the co-product, caustic soda. Quite recently there has been some additional publicity indicating perfection of the Deacon process for reclaiming chlorine from hydrogen chloride. If such a process becomes economically feasible and efficient, it is possible that much future expansion could be in this direction. If economics of this process are improving, it is most likely that it will be installed in places which are a considerable distance from present chlorine producing points so that the benefit of the highest price for chlorine (f. o. b. price plus freight) can be obtained. Of equal probability is the use of hydrogen chloride from by-product sources to substitute for chlorine in traditional reactions. For example, much of the vinyl chloride in this country today is made from virgin chloride. With cheaper acetylene processes coming into the picture, by-product hydrogen chloride is a more economical source of chlorine and may well be substituted. In addition, there is some evidence to indicate that ways may be found to activate hydrogen chloride through proper catalysts to provide chlorine *in situ* in certain reactions. Higher prices on chlorine, which seem probable in the future, will bring about additional pressure for one of the solutions just described.

Caustic Soda vs. Soda Ash

A tabulation is presented in Table 2 listing the principal consuming industries for soda ash alone, for caustic soda alone, and also for those industries or end-uses where soda ash and caustic soda may be used interchangeably. Table 3 and Figure 2 give production and capacity figures of both lime-soda caustic, electrolytic caustic soda, and also the production capacity for ammonia soda ash and natural soda ash. These are data pertinent to an analysis of the potentialities of caustic soda in making inroads on the normal soda-ash market. The figures from 1949 through 1957 have been resolved fairly accurately. The forecast for 1960 and also for 1965 has been based on the growth trend and the outlook of these chemicals in their markets and in any new markets.

In a glance at the list of end-uses for caustic soda and soda ash, it will be noted that there are specific uses for soda ash, where practically all the requirement is for ash, and also similar requirements for caustic soda. In the category where both chemicals are important, that is, in chemicals, soap and cleaners, pulp and paper, metal processing, and others, a large tonnage exists. The problem of whether to use caustic soda or soda ash is mainly an economic one rather than a matter of chemical superiority. The important ingredient is the alkali effect of the chemical and, therefore, the process may be designed to use either alkali interchangeably.

It is natural for caustic soda producers to eye the soda-ash market as the easiest and quickest opportunity to

Fig. 1. Caustic soda and chlorine production, 1925 to present, with projections to 1965.

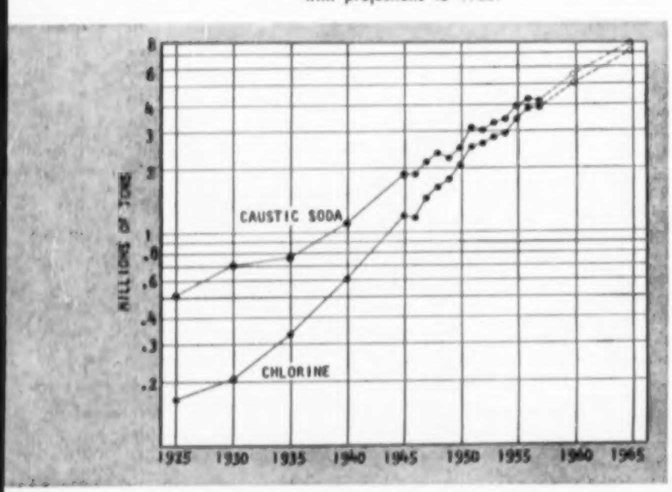
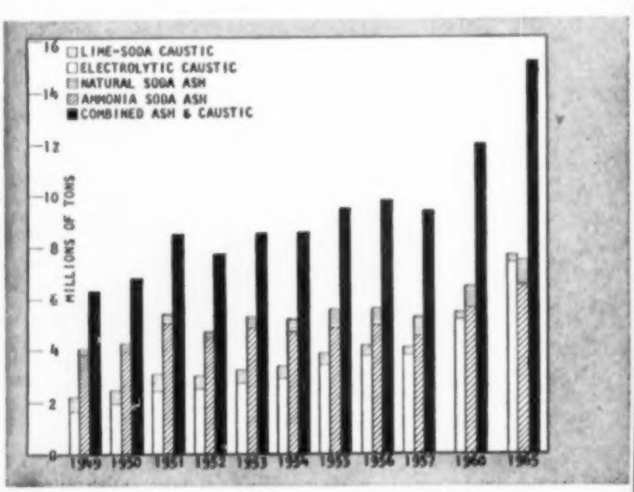


Fig. 2. Caustic soda and soda ash production 1949-1965.



find an outlet for increasing production. The obstacles are two: (1) traditional usage of soda ash and equipment designed to handle it in existing plants, and (2) a serious price barrier. The latter may be described in this wise:

Most caustic soda is purchased as 50% liquor and most soda ash is used as bulk light ash. Current market price for caustic soda is \$58.00/ton for 50% liquor on a basis of 76% Na_2O content. The current market price for light soda ash is \$31.00/ton on a basis of 58% Na_2O. The cost margin of \$27.00/ton, then, actually amounts to about \$22.87/ton when expressed on an equivalent Na_2O basis. These prices are f.o.b. seller's plant; therefore, freight must be taken into account to obtain a true evaluation.

In some cases, part of this margin can be overcome by the greater ease with which the liquid product can be handled, shipped, and stored, but in most cases as long as the differential exists the choice is in favor of soda ash. Furthermore, there are instances in which production economics might justify a caustic soda producer making a lower price to reduce the differential even more. For example, in a case where a producing plant and a consuming plant were adjacent and "over-the-fence," deliveries could be achieved, possibly at a lower concentration than 50%. The shipper would save in loading charges, investment in tank cars, evaporation equipment, steam costs, purification costs, freight equalization costs, etc. Thus, there are in the country a limited number of opportunities for the manufacturers of caustic soda to be on a competitive basis with makers of soda ash.

One of the biggest markets where the two products are interchangeable and which has shown a trend toward the use of caustic soda in new plants is in the metallurgical industry. Particularly for the manufacture of alumina, either soda ash or caustic soda, depending upon availability and cost, may be used. The older plants, because of their design and the fact that the equipment has already been installed and largely written off, normally prefer soda ash. However, newer plants are often built to use the products interchangeably.

Lime-soda Caustic vs. Electrolytic

Most of the new caustic soda capacity in recent years has employed the electrolytic process. Much of it has been brought in at the expense of lime-soda plants. There is still a considerable tonnage of lime-soda caustic produced and presumably this caustic could be replaced by electrolytic caustic in the future. The cutting off of lime-soda caustic facilities is getting to be less and less of a factor as the production of electrolytic caustic grows. From a position where lime soda accounted for 20% of the total caustic production in 1950, it had declined to 17% in 1954 and is estimated to be less than 10% in 1960. The elimination of this 10%, which might be as much as 300,000 to 350,000 tons/yr., although a significant amount, would not delay too long the oversupply situation. Furthermore, it cannot be assumed that because additional electrolytic facilities are built, lime-soda plants will automatically shut down. Actually, those lime-soda plants still in operation are owned by large and stable concerns in the alkali industry. It is a fair assumption that they will continue to be competitive and to hold their customer position and will shut down only when the manufacturers, themselves, can replace this capacity with electrolytic capacity or can find some other usage for the equipment in the lime-soda plant.

In a move to combat this situation, the manufacturers of electrolytic caustic soda are looking with considerable interest at the possibility of manufacturing soda ash from diaphragm cell liquor. This potentiality, of course, is a complete reversal of the traditional situation for instead of making caustic soda out of soda ash, now the thinking is in terms of making soda ash out of caustic. However, it is not quite as simple as that.

Caustic cell liquor is a weak alkali solution containing only about 10% caustic soda as it comes from the cells. This is not as uneconomic as it might seem at first blush. The cell liquor can be used as the raw material for soda ash rather than carbonated brine and the equipment for final conversion into soda ash is much less costly than the conversion into soda ash by the ammonia soda process. Steady increases in cost of equipment today are making it virtually impossible to build a new soda-ash plant and sell the product at prevailing market prices. On the other hand, it is sometimes economic to convert existing ammonia soda capacity which is being diverted to lime-soda caustic into finished soda ash. As additional soda-ash capacity is required, this may be one of the important sources of such capacity.

Effect of Prices

Prices are, of course, a motivating force in influencing technological decisions on both production and consumption of chemicals. Traditionally, chlorine and caustic soda have been priced on the basis of the manufacturing cost (Table 4 and Figure 3). This is a normal procedure for chemical

Fig. 3. Chlorine-alkali price trends 1930-1957.

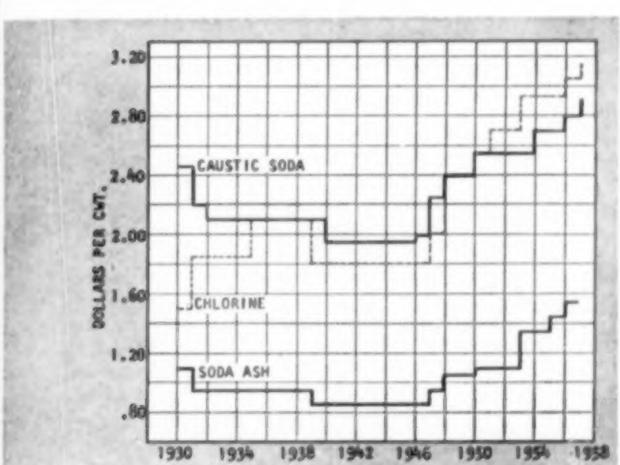


Fig. 4. Production of chlorine and alkalies (Na_2O equivalent) 1925 to present, with projections to 1965.

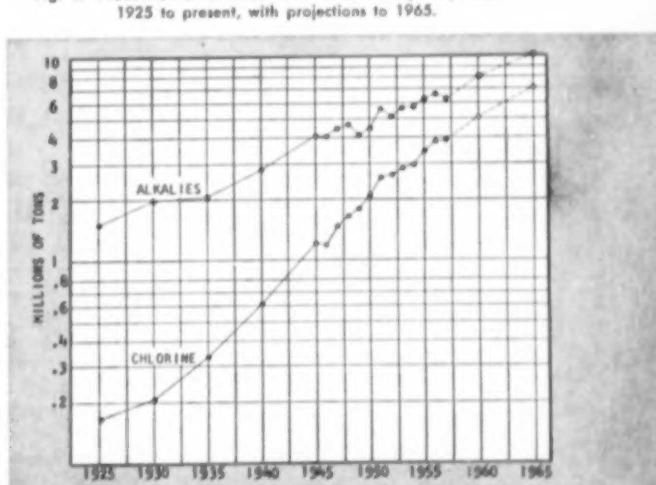


Table 2.—End-Uses for Caustic Soda and Soda Ash (1956)

Caustic soda (tons)		Soda ash (tons)
	Practically all ash	
	Glass	1,590,000
	Caustic & bicarb.	696,000
	Water treatment	120,000
	Both important	
1,155,000	Other chemicals	1,383,000
80,000	Soap	80,000
161,000	Other cleaners	160,000
285,000	Pulp & paper	339,000
100,000	Metals processing	614,000
1,270,000	Exports & miscellaneous	672,000
	Practically all caustic	
640,000	Rayon & film	
284,000	Petroleum refining	
135,000	Textile processing	
50,000	Vegetable oil refining	
50,000	Reclaimed rubber	
4,210,000	Totals	5,654,000

Table 5.

PRODUCTION
(thousand tons)

	Caustic soda	Soda ash	Total	Chlorine
	Na_2O Basis			
1925	385	1,107	1,492	165
30	532	1,438	1,970	205
35	578	1,455	2,033	330
40	836	1,935	2,771	605
45	1,417	2,643	4,060	1,192
1946	1,423	2,608	4,031	1,165
47	1,622	2,784	4,406	1,447
48	1,792	2,826	4,618	1,621
49	1,689	2,389	4,078	1,767
50	1,890	2,511	4,401	2,069
1951	2,354	3,155	5,509	2,511
52	2,288	2,758	5,046	2,596
53	2,479	3,073	5,552	2,796
54	2,576	3,023	5,599	2,893
55	2,969	3,246	6,215	3,408
1956	3,202	3,279	6,481	3,783
57	3,145	3,069	6,214	3,846
*1960	4,180	3,770	7,950	5,000
*1965	5,852	4,350	10,202	7,000

* Estimated. Source: U. S. Dept. of Commerce.

manufacturers. In other words, a manufacturer will figure that it costs so much to operate an electrolytic cell, these costs being divided between chlorine and caustic soda on a pro rata basis. Additional costs of evaporating the caustic to a salable product are added to caustic and the additional costs of liquefaction of the chlorine are added to chlorine. Then these figures on costs form a basis for determining a market price. If in the future the chlorine manufacturer is unable to market his caustic soda and still requires chlorine, this situation calls for a reevaluation of allocation of costs. Then the entire operation of the chlorine cell must be borne by the chlorine alone. Carried to an extreme, this would mean that the caustic soda would have to be disposed of—perhaps in a disposal well—and the cost of disposal added to chlorine as well. Under such circumstances, the price of chlorine would be driven up to levels where other processes might become extremely attractive. This procedure might apply in isolated instances. However, before any widespread disposal of caustic soda cell liquor occurs, it is likely that there will be some price or use adjustment in an effort to reach new markets, as indicated previously in the case of the soda-ash market.

It is understood that increased costs of building and operating chlor-alkali plants will induce a tendency to convert present lime-soda caustic facilities to finished soda-ash facilities. Beyond this, there will probably be a tendency to make finished soda ash from caustic soda diaphragm cell liquor (Table 5 and Figure 4). Because of the close interrelationship between soda ash and caustic soda, it is thought that Figure 4 may present more clearly than the chlorine and caustic soda figure the over-all picture.

Location of New Plants

In the past, the tendency has been for the chlor-alkali industry and the soda-ash industry to locate plants near the most economic source of raw material. This has meant that most plants were located over a salt bed and adjacent to low-cost power. It develops that with increasing transportation costs, the cost of transporting the products to market often can balance the cost of transporting salt to the plant. Therefore, if a plant can be located adjacent to chlorine and caustic soda consumers, the increased cost of raw material is not necessarily an insurmountable objection. Notwithstanding, a chlor-alkali plant still requires a low-cost source of power. Thus, it is reasonable to expect that some future plant expansions will tend to be located near consuming plants rather than near raw material sources.

Storage Questions

Another significant trend in the industry will be the creation of more storage depots. One major producer now has a substantial number of storages for liquid caustic soda located throughout the country. All these storages are connected by water transportation, thus minimizing over-all transportation costs and providing the ultimate in customer service. Because of constantly increasing material costs, the future plant installations will probably have to be large in design in order to return an ample percentage on the dollar investment. Improvements in cell design and better utilization for raw materials, plus increased technology of operation, will all need to be employed to justify future expansions.

Presented at A.I.Ch.E. meeting, Baltimore, Maryland.

Table 3.

PRODUCTION
(thousand tons)

	Electrolytic caustic	Lime soda caustic	Ammonia soda ash	Natural soda ash	Total
1949	1,656	566	3,916	203	6,341
1950	1,983	504	3,991	338	6,816
1951	2,430	668	5,094	346	8,538
1952	2,500	511	4,442	313	7,766
1953	2,758	504	4,879	419	8,560
1954	2,911	479	4,701	511	8,602
1955	3,441	466	4,907	689	9,503
1956	3,791	422	4,998	656	9,867
1957	3,804	334	4,594	697	9,429
*1960	5,200	300	5,660	840	12,000
*1965	7,400	300	6,530	970	15,200

* Estimated.

History

In 1955, the Becco Chemical Division announced the availability of tonnage quantities of hydrogen peroxide in concentrations up to 99.7% H_2O_2 or virtually anhydrous hydrogen peroxide. Thus, a laboratory phenomenon was introduced as a production commodity of considerable interest to the rocket industry because of its high energy and oxidizing power and also because of its storage stability when containers made of proper materials are used.

Previous to the development of this commercial process for production of anhydrous hydrogen peroxide, nominally 90% by wt. H_2O_2 was the highest concentration available in quantity. Anhydrous hydrogen peroxide has all the characteristics which make 90% H_2O_2 systems with catalytic decomposition reliable and simple. Added advantages are greater density and greater heat of decomposition than the 90% H_2O_2, which tend to increase energy output per unit weight and volume of gas generator systems, and the disadvantages of a higher freezing point and slightly decreased thermal stability. However, if these disadvantages are applicable to a particular situation, both can be overcome by engineering means because the advantages warrant it.

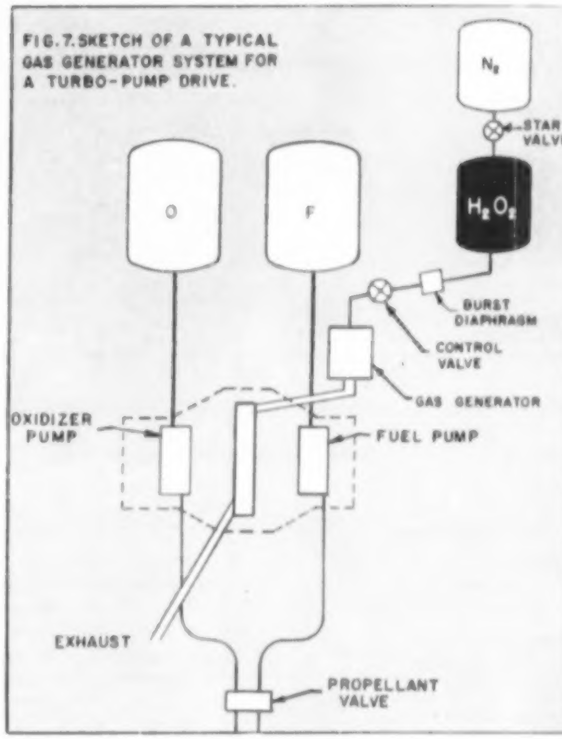


FIG. 7. SKETCH OF A TYPICAL GAS GENERATOR SYSTEM FOR A TURBO-PUMP DRIVE.

Anhydrous hydrogen peroxide as a propellant

The first commercial-scale process for the production of anhydrous hydrogen peroxide has far-reaching economic and strategic implications in the field of missile propellants. Here are the details of the concentration-type process employed and data on the properties of the newly available concentrated product.

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Properties of anhydrous hydrogen peroxide and its application as a propellant are discussed here with a description of the manufacturing process. Anhydrous hydrogen peroxide is compared with 90% H_2O_2 and other propellants from a performance standpoint with the use of authoritative published data, wherever possible.

Manufacturing Process

Anhydrous hydrogen peroxide is manufactured by a unique process for concentrating hydrogen peroxide solutions. This process utilizes the freezing properties of these solutions to accomplish fractional crystallization. Inspection of the solid-liquid equilibrium curve of H_2O_2-water solutions (Figure 1) reveals that the crystalline phase is more concentrated and thus more dense than the liquid phase. Hence, a solid phase of progressively higher hydrogen peroxide content will move downward through a column while a liquid phase progressively poor in hydrogen peroxide moves up the column.

Apparatus for accomplishing this process *(8)* is shown in Figure 2. To produce anhydrous hydrogen peroxide in this apparatus, 90% H_2O_2 is fed to the crystallizer which is at the top, and the product is withdrawn from the bottom of the warmed column. This new process is an ideal complement to fractional distillation, which is commercially practical only up to about 90% H_2O_2, because it yields a commercial product concentration of 98% H_2O_2 and can be made to produce 99.7% H_2O_2.

In addition, the crystallization process also rejects most of the impurities. The feed stock, 90% H_2O_2, already meets ACS specification for reagent grade 30% H_2O_2, the only concentration for

Table 1.—Physical Properties of Hydrogen Peroxide

Property	Conditions	Units	Concentration, wt. % 90	98	100
Density	77° F.	lb./gal.	11.57	11.95	12.04
Boiling point	1.0 atm.	° F.	286.2	299.2	302.4
Freezing point	1.0 atm.	° F.	11.3	27.5	31.3
Refractive index, Sodium D-Line	77° F.	—	1.3980	1.4049	1.4067
Vapor pressure	77° F.	mm.Hg	3.8	2.2	2.0
Electrical conductivity	77° F.	10^{-6}ohm^{-1}cm.$^{-1}$	1.9	0.8	0.5
Viscosity	77° F.	centipoise	1.153	1.155	1.156
	32° F.	centipoise	1.860	1.810	1.798
Surface tension	68° F.	dynes/cm.	79.3	80.2	80.4
Total heat of vaporization	77° F.	B.t.u./lb. sol.	700.3	662.0	652.8
Dielectric constant	68° F.	—	77	74	73

Table 2.—Typical Reactions of H_2O_2

Oxidation

$(C_2H_5)_2NH$ Diethylamine $\xrightarrow{H_2O_2}$ $(C_2H_5)_2NOH$ Diethylhydroxylamine

Reduction

$KMNO_4 + H_2SO_4$ potassium permanganate $\xrightarrow{H_2O_2}$ $MnSO_4$ Manganous sulfate

Formation of per-acids

CH_3COOH Acetic acid $\xrightarrow{H_2O_2}$ CH_3COOOH Peracetic acid

Molecular addition

$CO(NH_2)_2$ Urea $\xrightarrow{H_2O_2}$ $CO(NH_2)_2 \cdot H_2O_2$ Urea peroxide

Oxygen generation

H_2O_2 Hydrogen peroxide $\xrightarrow{\text{Catalyst}}$ $H_2O + \frac{1}{2} O_2$ water oxygen

Table 3.—Chemical and Thermal Properties of Hydrogen Peroxide *(1)*

Property	Conditions	Units	Concentration, wt. % 90	98	100
Avg. molecular weight	—		31.241	33.422	34.016
Active oxygen	—	wt. %	42.3	46.9	47.0
Heat of decomposition	77° F., 1.0 atm.	B.t.u./lb. sol.	1108.	1215	1240
Adiabatic decomposition temp.	1.0 atm.	° F.	1364	1735	1824
Heat of dilution to infinite dilution	77° F.	B.t.u./lb. sol.	−31.2	−41.0	−43.3
Total heat of vaporization	77° F.	B.t.u./lb. sol.	700.3	662.0	652.8
Mean heat capacity	32-81° F.	B.t.u./lb.sol./° F.	0.660	0.635	0.628
	500° F. (9)		0.813	0.780	0.772
Critical temperature	—	° F.	—	—	855
Critcal pressure	—	atm.	—	—	214

Table 4.—Decomposition Products *(1)*

Property	Initial concentration, wt. %, H_2O_2 90	98	100
Mole fraction H_2O	0.7076	0.6748	0.6667
Mole fraction O_2	0.2924	0.3252	0.3333
Gas composition, wt.% H_2O	57.7	53.1	53.0
Gas composition, wt.% O_2	42.3	46.9	47.0
Avg. molecular weight	22.10	22.57	22.68
Temperature, ° F.	1364	1735	1824
Gas volume, cu.ft.*	60.2	70.8	73.5
Cp/C_v of products	1.266	1.251	1.248

* Volume of gas liberated at 1.0 atm. at adiabatic decomposition temperature, from 1 lb. of solution at 68° F.

which an ACS reagent grade specification exists. Thus, the impurity level in 98-99.7% H_2O_2 is much less than that allowed by the current ACS reagent specifications.

Physical Properties

Anhydrous hydrogen peroxide, like 90% H_2O_2, is a clear, colorless liquid soluble in all proportions in water and in most substances which are miscible with water (Figure 3).

Like all hydrogen peroxide solutions, it must be kept in containers made of non-catalytic materials to avoid decomposition. The surface of such containers in contact with the liquid must be passivated, or streamers of oxygen gas from the slowly decomposing hydrogen peroxide will be evident. The photograph (Figure 3) shows beakers of water, 98% H_2O_2 in passivated glass and of 98% H_2O_2 in nonpassivated glass. Slight decomposition is evident in the beaker which has not been passivated. If concentrations of hydrogen peroxide solutions are stirred rapidly, some effervescence is noted because of release of dissolved oxygen.

A representative list of physical properties *(1)* of 100%, 98%, and 90% H_2O_2 is presented in Table 1.

The high density of concentrated hydrogen peroxide solutions is a distinct advantage in propellant applications due to the smaller space requirement per unit weight. The 100% product has an even greater density than the 90% H_2O_2.

The low viscosity of hydrogen peroxide under usual temperature conditions is an advantage in propellant systems since pumping must be accomplished efficiently under a variety of conditions of temperature and pressure. The viscosities of 90 and 100% H_2O_2 are practically identical. Although no measurements are available, the viscosity of supercooled solutions at low temperatures is significantly higher than that for solutions at temperatures above the freezing point.

One of the chief disadvantages in the use of 90% H_2O_2 for some cold-weather applications is the high freezing point (11.3° F.) The freezing point of 100% H_2O_2 is even higher, (31.3° F.); however, there is a strong tendency for these solutions to supercool as much as 25 to 40° F. below the true freezing point *(2)*. In some instances, these concentrated hydrogen peroxide solutions have been held for hours at 70 to 80° F. below the true freezing point.

The crystallizing process for manufacture of anhydrous hydrogen peroxide tends to reject dissolved impurities as well as water. Normal 90% H_2O_2 is readily obtainable with purity comparable to that of carefully distilled water. If such a product is even more carefully purified as in the manufacture of anhydrous hydrogen peroxide, supercooling should be even more pronounced and, barring introduction of nuclei, freezing should be no problem

Fig. 3. Appearance of anhydrous H_2O_2 in clean and dirty beakers compared to water. Left, water; center, H_2O_2 in passivated beaker; right, H_2O_2 in unpassivated beaker.

except under the most extreme conditions. However, if freezing of the hydrogen peroxide does occur, the density of the solid hydrogen peroxide is 1.71 g./cc. compared to 1.47 g./ml. for the liquid anhydrous hydrogen peroxide at 32° F. Thus, the solution will contract upon freezing and container rupture is not a problem. This property and the fact that hydrogen peroxide decomposition can provide heat suggests the possibility of storing anhydrous hydrogen peroxide as a solid and then of starting decomposition of a portion of it to melt the mass when it is to be used.

As shown in Table 1, the vapor pressure of hydrogen peroxide is very low. At normal temperatures no special ventilation precautions are necessary since the quantity of hydrogen peroxide in the vapor over the surface is negligible. It has been shown, however (*3*), that vapor concentrations over 26 mole % H_2O_2 are sensitive to hot surfaces or sparks. Fortunately, because of the low vapor pressure and therefore the high boiling point, these concentrations are never attained in routine use.

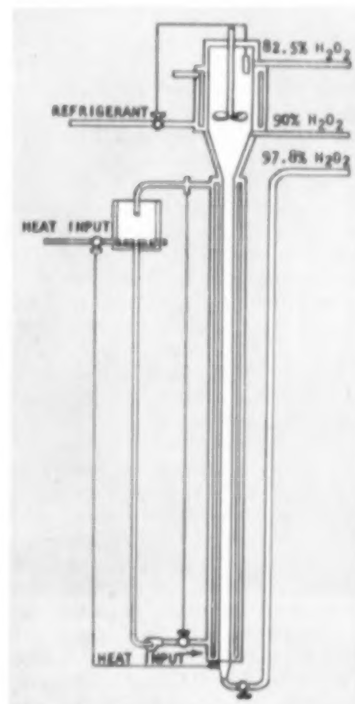
Chemical and Thermal Properties

Anhydrous hydrogen peroxide exhibits the same general oxidizing properties known for the more dilute solutions. The absence of diluent water and, therefore, the increased concentration of oxidizing agent as well as the increased solubility in organic media lead to increased efficiency. A very few of the general types of reactions possible are shown in Table 2.

Hydrogen peroxide can act either as an oxidizing agent as in the first reaction, or as a reductant, as shown in the second. This latter reaction is useful for analysis of hydrogen peroxide solutions. Of particular interest to the present discussion is the last reaction shown in Table 2. Hydrogen peroxide when catalytically decomposed releases water vapor, oxygen gas, and heat.

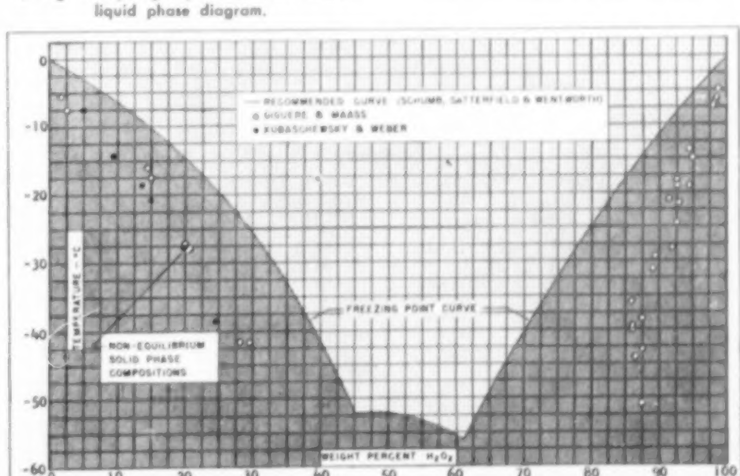
Anhydrous hydrogen peroxide is a much richer source of heat than is 90% H_2O_2 as shown in Table 3. The active oxygen content has been increased from 42 to 47% and the decomposition temperature from 1,364 to 1,824° F. The specific heat ratio, however, is lower than that for 90% H_2O_2 decomposition products because of the higher temperature, but the volume of gas produced from 1 lb. H_2O_2 solution is almost 74 cu. ft. compared to 60 cu. ft. for 90% H_2O_2 (Table 4).

Of great importance to the propellant field is the analysis of hydrogen peroxide solutions for concentration. Because the main diluting impurity is water, and no satisfactory method exists for determining water in hydrogen peroxide at these concentration levels, a direct determination of hydrogen peroxide must be made. Since the concentrations involved are between 90 and 100% H_2O_2, the usual volumetric determinations involving titration with potassium permanganate or with ceric sulfate require use of weight burettes and the most precise analytical technique. Another method of analysis that has been found quite satisfactory, is through use of a dipping refractometer. Since a refractive index change of 0.0002 represents a concentration change of 0.2%, a most precise measurement must be made. The concentration can be determined by change in density, but, because of formation of bubbles of oxygen gas on the glass surfaces of the measuring instruments, this method is usually not used for exact analysis. An incompletely explored method of analysis uses the adiabatic decomposition temperature as a basis. The decomposition temperature changes 89° F. for the concentration change from 98 to 100%. The difficulty here, of course, lies in obtaining true adiabatic conditions in the measuring device. The analysis unit developed by Redstone



▲ Fig. 2. Apparatus for manufacturing anhydrous hydrogen peroxide. (8)

▼ Fig. 1. Hydrogen peroxide-water solid-liquid phase diagram.



Arsenal and described in a recent publication *(4)* has not been evaluated for anhydrous hydrogen peroxide analysis.

Performance Characteristics

The foregoing discussions on physical, chemical, and thermal properties indicate the potential of anhydrous hydrogen peroxide as a propellant. Hydrogen peroxide is a homogeneous solution which can readily be decomposed to produce hot gases for power generation, pressurizing gas, or for heating purposes. The 98% H_2O_2 adiabatic decomposition temperature of 1,735° F. can be nearly approached in practice. This temperature is about the maximum that can be accommodated in an uncooled decomposition chamber.

It has been demonstrated that anhydrous hydrogen peroxide can be readily decomposed catalytically with the use of a solid catalyst bed in a chamber such as the one shown in Figure 4. Materials, catalytic to the decomposition of anhydrous hydrogen peroxide, are, naturally, the same ones that are catalytic to 90% H_2O_2 decomposition, namely the permanganates, heavy metals, and the oxides of heavy metals. In selecting a catalyst for anhydrous hydrogen peroxide one must consider the high decomposition temperature.

The rate of catalytic decomposition of anhydrous hydrogen peroxide should be greater than that of 90% H_2O_2, although this has not been actually measured. Because of the increased reaction temperature, it is to be expected that more propellant can be decomposed per unit weight and volume of catalyst than for a 90% H_2O_2 system at comparable pressures and inlet temperatures. In fact, the reaction rate might actually be high enough to permit a practical rate of sustained thermal decomposition eliminating all catalyst except for initiation of the decomposition reaction.

Preliminary tests have been run that demonstrated the possibility of thermal decomposition of anhydrous hydrogen peroxide. In a scrupulously passivated open stainless steel beaker, heating of the hydrogen peroxide at various rates resulted in: (*1*) smooth transition to thermal decomposition at a temperature of 133-138° C. at medium heating rates, or (*2*) superheating of the liquid followed by violent expulsion of the liquid from the beaker and explosions at temperatures of 136-143° C. at medium and low heating rates. For these preliminary tests 180-200 ml. of H_2O_2 was heated in a 300-ml. heavy-walled stainless steel beaker and 100 ml. in a thin-walled stainless steel beaker with the use of a 3-position hot plate. The test program was terminated before the mechanism of the reactions experienced was determined.

A brief series of flow tests was carried out using the decomposition chamber shown in Figure 5, packed with 60-mesh Ottawa silica sand which was shown to be inert with hydrogen peroxide at ambient temperatures. In this chamber some difficulty was found in attaining consistent starts because of preheating of the inlet pipe during the chamber preheating period. However, three satisfactory runs were attained and these indicated that thermal decomposition of 98% H_2O_2 was feasible. Initiation of the reaction was attained at temperatures of 302 to 400° F. Steady running was carried out at equilibrium pressures of 445, 540, and 655 lb./sq.in. gauge, with relatively high flow rates. Complete decomposition was attained as determined by condensation and titration of the discharge gases although measured gas temperatures were a maximum of only 1,616° F. The maximum feed rate, which was limited by the apparatus and not by flooding, was more than eight times the limiting flow rate for 90% H_2O_2 in a chamber with similar packing.

Performance of anhydrous hydrogen peroxide as a propellant is superior to that of 90% H_2O_2 because of its higher energy of decomposition and greater liquid density. Other factors such as molecular weight, composition, and specific heat ratio of the decomposition gases remain nearly equal. A comparison of 90, 95, and 100% H_2O_2 *(5)* is shown in Table 5. These data indicate a performance advantage based on density impulse of approximately 15.3% when anhydrous hydrogen peroxide is substituted for 90% H_2O_2 in a gas generator system with a 20 : 1 expansion ratio and 16.3% advantage for a 6.8 : 1 expansion ratio. For rocket applications, performance is rated in terms of specific impulse (I_{sp}), which is pounds thrust/pound propellant per second, and density impulse (I_d), which is pounds thrust/unit volume propellant per second. The I_{sp} and I_d values for 90 and 100% H_2O_2 for various expansion ratios on a frozen equilibrium basis are shown in Figure 6. At high pressures there is insignificant dissociation of hydrogen peroxide decomposition products. For each H_2O_2 concentration there is a limiting expansion ratio for production of homogeneous gaseous decomposition products. At greater expansion ratios condensation occurs resulting in heterogeneous wet steam. Turbine operation would be undesirable under such conditions and rocket nozzles would have to be designed properly to take full thermodynamic advantage of the heat available.

Applications of the monopropellant characteristics of anhydrous hydrogen peroxide can be similar to those of 90% H_2O_2. Large gas generators for turbopumps and auxiliary power units could take the greatest advantage of the increased performance, simplicity, and reliability of anhydrous hydrogen peroxide. A typical gas generator system is shown in Figure 7. Such hydrogen peroxide gas generators using 76-90% H_2O_2 have been employed in the engines for the V-2, Viking, Vanguard, and Redstone missiles.

Other types of applications in which

Table 5.—Performance Data *(5)* for 90, 95, and 100% Hydrogen Peroxide

H_2O_2 concen. wt. %	Chamber press lb./sq.in.abs.	Specific impulse, sec.	Density impulse, sec. (77° F.)	Chamber temp., ° F.)	C*, ft./sec.	Entropy B.t.u./(° F.)(lb.)	Enthalpy B.t.u./lb.	Specific heat ratio
90	100	111.3	153	1355	3057.5	2.4351	—2870	1.271
95	100	117.5	166	1590	3235.9	2.4599	—2670	1.262
100	100	123.6	178	1820	3397.9	2.4780	—2480	1.253
90	300	131.9	183	1364	3062.2	2.3364	—2970	1.266
95	300	139.1	197	1603	3247.4	2.3641	—2785	1.261
100	300	146.7	211	1830	3404.4	2.3825	—2610	1.253
90	1000	146.5	203	1382	3086.0	2.2295	—3050	1.270
95	1000	154.7	218	1638	3278.9	2.2618	—2885	1.260
100	1000	163.4	236	1855	3426.7	2.2794	—2720	1.252

C* = characteristic exhaust velocity

anhydrous hydrogen peroxide would be advantageous as a monopropellant are as follows:

1. The rocket on rotor helicopter power assist system
2. Attitude and roll control motors for missiles
3. Target drone or test unit propulsion.

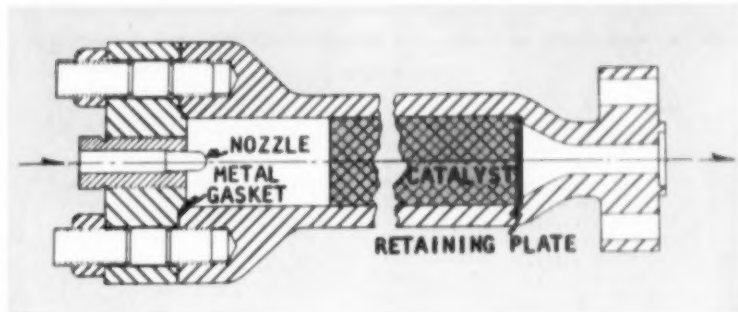
Handling and Storage Characteristics

Handling and storage characteristics of anhydrous hydrogen peroxide are, in general, similar to those for 90% H_2O_2. Anhydrous hydrogen peroxide has shown a greater storage stability at ambient temperatures due to its extreme purity, but a greater sensitivity to heat due probably to the greater tendency for the liquid to superheat, as described previously, and to formation of explosive vapor concentrations at a lower temperature than the limit for 90% H_2O_2. It is also more reactive than 90% H_2O_2 due to its greater energy content and this is revealed in quicker ignition of combustibles upon contact. This means a short delay time which requires prompt action with diluent water when an accidental spillage occurs. Naturally, water must be available wherever anhydrous hydrogen peroxide is handled because prompt dilution of spillage of combustibles will prevent ignition, and dilution of contaminated material will prevent development of a dangerously high temperature and rate of decomposition.

Anhydrous hydrogen peroxide in contact with the skin results in irritation that is evidenced slightly more rapidly than when 90% H_2O_2 comes in contact with the skin. Water is the antidote. Contact with the eye should be avoided and protective goggles must be worn at all times. However, if such contact should occur, the eye must be washed promptly with water and then medical treatment should be obtained. Protective clothing suitable for handling anhydrous hydrogen peroxide should be made of Dynel, Dacron, polyvinyl-chloride or rubber similar to that used for handling 90% H_2O_2, as described in the Navy Bureau of Aeronautics Handbook, NavAer Publication 06-25-501 (*6*).

Freezing of anhydrous hydrogen peroxide may occur at higher temperatures than for 90% H_2O_2. However, as stated previously, there is a strong tendency for anhydrous hydrogen peroxide to supercool under practical conditions of use, which may be much greater than for 90% H_2O_2 owing to the extreme purity.

Materials of construction have been evaluated to some extent for anhydrous hydrogen peroxide service. Table 6 lists the materials which have been



▲ Fig. 4. Typical solid bed catalyst chamber for decomposition of anhydrous H_2O_2.

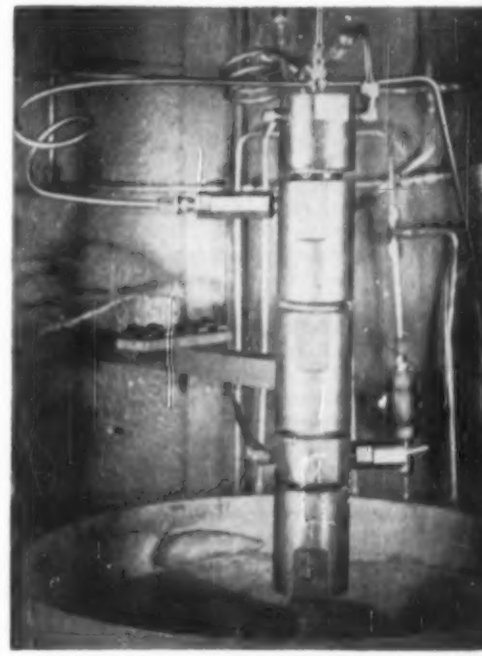


Fig. 5. Test reactor for thermal ▶ decomposition of anhydrous H_2O_2.

Fig. 6. Performance curves for H_2O_2 monopropellants, specific impulse and density impulse vs. chamber pressure for 90% and 100% H_2O_2 expanded to one atmosphere pressure. ▼ (5)

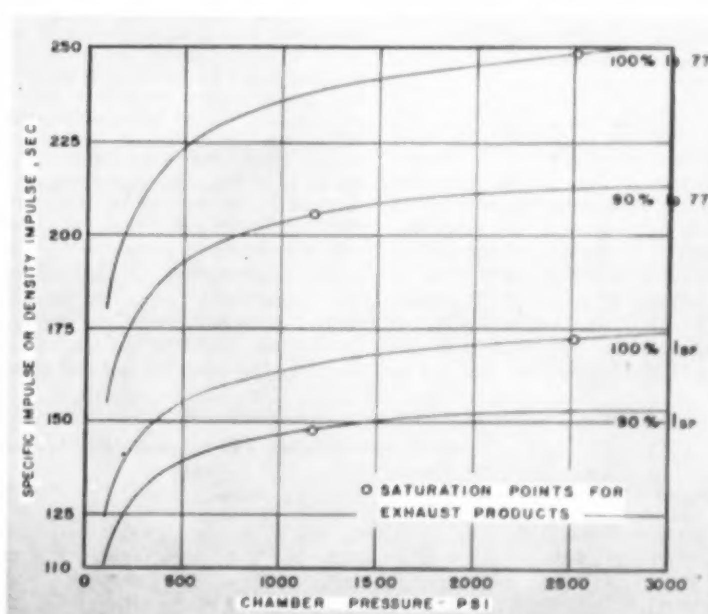


Table 6.—Compatibility of Construction Materials with 90% and Anhydrous H_2O_2

Material	Active O_2 loss, %/week 90% 30° C.	90% 66° C.	Anhydrous 30° C.	Anhydrous 66° C.	Effect on samples
1060 Aluminum (99.6)	0.2	3.1	0.4	1.5	None
5052 Aluminum	0.2	8.3	1.1	2.6	None
7072 Aluminum	0.2	2.1	0.3	4.1	None
6061 Aluminum	3.4	12.0	1.2	5.2	None
2024 Aluminum	—	100	0.5	100	Pitted
355 Cast aluminum	3.3	100	0.2	100	None
356 Cast aluminum	0.7	50.0	0.2	3.9	None
304 Stainless steel	1.1	50.0	1.5	12.0	Slight bronzing at higher temp. for all samples.
316 Stainless steel	4.4	47.0	3.2	53.0	
347 Stainless steel	2.8	57.0	6.4	30.0	
Polyethylene	0.4	2.0	0.5	2.3	None
Kel-F	—	3.2	0.2	8.3	None
Teflon	0.4	2.5	1.1	2.6	None
Vinylite Vu 1930	0.5	2.4	0.9	2.7	Become opaque

tested and the results of the standard 30° C. (86° F.) and 66° C. (151° F.) accelerated compatibility tests. It is noted that in general, the materials suitable for 90% H_2O_2 service are suitable for anhydrous hydrogen peroxide service. Some plastics are attacked more severely by anhydrous hydrogen peroxide than by 90% H_2O_2, due to higher energy, greater oxygen content, and greater solvent power. With metals, anhydrous hydrogen peroxide generally shows less active oxygen loss than does 90% H_2O_2. This greater stability of anhydrous hydrogen peroxide in the presence of metals was found to result in greater storage stability in the pure aluminum shipping drums used for 90% H_2O_2 shipments. Results of storage of approximately 99% H_2O_2 in several drums in the laboratory are shown in Table 7. These results indicate excellent storage stability for anhydrous hydrogen peroxide in pure aluminum.

Elevated temperature vapor stability may be a problem under certain circumstances of use. The safe storage temperature curve (Figure 8), based on studies carried out at MIT, indicates attainment of the critical hydrogen peroxide vapor concentration of 26 mole % in equilibrium with liquid anhydrous hydrogen peroxide at 230° F. compared with 243° F. for 90% H_2O_2 at atmospheric pressure. Therefore, feed line heating must be avoided by taking care in anhydrous hydrogen peroxide systems that they will not be subject to radiation or convection from the decomposition chamber.

Sensitivity of liquid anhydrous hydrogen peroxide to impact under various degrees of confinement has been evaluated. Drop weight tests were performed at Becco with a modified Bureau of Mines liquid explosive impact tester. At temperatures up to 212° F. and impacts up to 3 kg. m. (7 ft. lb.) negative results were obtained in all tests. Pipe tests with high explosive boosters were carried out by the U.S. Bureau of Mines at the Test Center, Bruceton, Pennsylvania, in stainless steel tubes of ½,- ¾,- and 1-in. I.D. The results of these tests presented in Table 8, indicated that 99% H_2O_2 could be detonated at ambient temperature in a high confinement 1-in. I.D., 0.17-in. wall tube of 24 or 48 in. in length when a 20-g. tetryl booster charge in the tube was used as the initiating force. A 10-g. tetryl charge was insufficient to initiate a propagating detonation. Detonations were not attained in ½- or ¾-in. I.D., 0.14 and 0.15 in. thick walled tubes even with initiating charges of up to 40 g. tetryl. In one test in a 4-ft. length of 1-in. I.D., 0.18-in. wall stainless steel tubing coupled to a 16-ft. length of ½-in. I.D., 0.047-in. wall stainless steel tubing, all filled with 99% H_2O_2, there was no propagation of the detonation in the ½-in. tubing, although the hydrogen peroxide in the 1-in. tubing was completely detonated by the 40 g. tetryl initiating charge.

The combinations of confinement and shock which resulted in positive results were considered to be far greater than would be found in actual practice. However, the fact that some positive results were attained at a lower shock than with 90% H_2O_2 is indicative of the additional energy available in anhydrous hydrogen peroxide.

To evaluate further the possibility of hazards during shipping, anhydrous hydrogen peroxide was submitted to shock tests in standard, pure aluminum 30-gal. shipping drums. In these tests, 15 g. of dynamite (Herkomite) were placed in a glass vial in the center of 300 lb. (approx. 25 gal.) of anhydrous hydrogen peroxide and set off with a No. 6 electric blasting cap. The size of the dynamite charge was the maximum that could be set off in water in an hydrogen peroxide shipping drum without rupturing the drum. The tests were run at an ambient temperature of 54° F., and after heating the hydrogen peroxide in the drum to 160° F., as indicated by a thermocouple in a liquid.

There was no detonation in either test and the damage to the drums was only slightly greater than that experienced in tests with water. Figure 9 shows the test drum following the elevated temperature test of 99.5% H_2O_2. These tests indicated that anhydrous hydrogen peroxide in the standard shipping drums in 300-lb. quantities is insensitive to severe internal shock even at a temperature of 160° F.

Contamination tests of anhydrous hydrogen peroxide have not been carried out; however, it is expected that results would be similar to deliberate contamination tests with 90% H_2O_2 although attainment of self-heating should occur in less time for a given amount of contamination in a given container because of the higher heat of decomposition. Self-heating occurs when the rate of heat liberation by the H_2O_2 decomposition exceeds the rate of heat transfer to the surroundings so that the reaction temperature continues to rise and accelerate itself until all the hydrogen peroxide is consumed. If this occurs in a container, the gas evolution rate may exceed the relief capacity of the vent and a pressure rupture of the container can result. A calculated time-temperature curve for anhydrous hydrogen peroxide in a 4,000-gal. tank car in still air at 77° F. with 50%/yr. decomposition rate is shown in Figure 10, along with a simi-

Table 7.—Storage History of Anhydrous H_2O_2 in Aluminum Drums

Drum 1 Elapsed time (mo.)	Drum 1 H_2O_2%	Drum 2 Elapsed time (mo.)	Drum 2 H_2O_2%	Drum 3 Elapsed time (mo.)	Drum 3 H_2O_2%	Drum 4 Elapsed time (mo.)	Drum 4 H_2O_2%	Drum 5 Elapsed time (mo.)	Drum 5 H_2O_2%
0	99.0	0	99.0	0	99.4	0	99.4	0	99.1
13	98.8	13	99.0	6	99.2	6	99.0	1	99.1
14	98.9	14	99.0	7	99.0	7	99.0	2	99.1

lar calculated curve for 90% H_2O_2 (*7*). This curve substantiates the opinion that self-heating might be attained more rapidly with anhydrous hydrogen peroxide; however, there is no reason to expect anhydrous hydrogen peroxide to be more sensitive to any given contaminant than is 90% H_2O_2.

An analysis of the information presented indicates that anhydrous hydrogen peroxide can be handled and stored safely and easily when care is taken to prevent undiluted spillage and contamination.

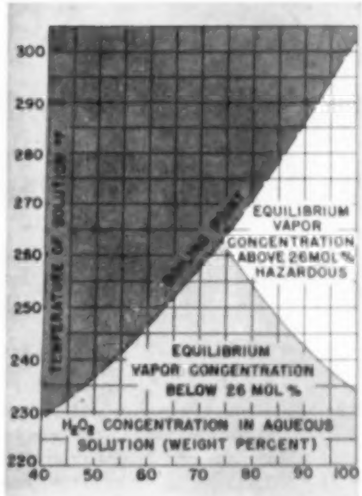


Fig. 8. Minimum temperatures for hazardous storage of H_2O_2-water.


Fig. 9. Becco 30-gal. aluminum H_2O_2 shipping drum after 15 g. of dynamite were set off in 20 gal. of 99.5% H_2O_2 at 160° F.

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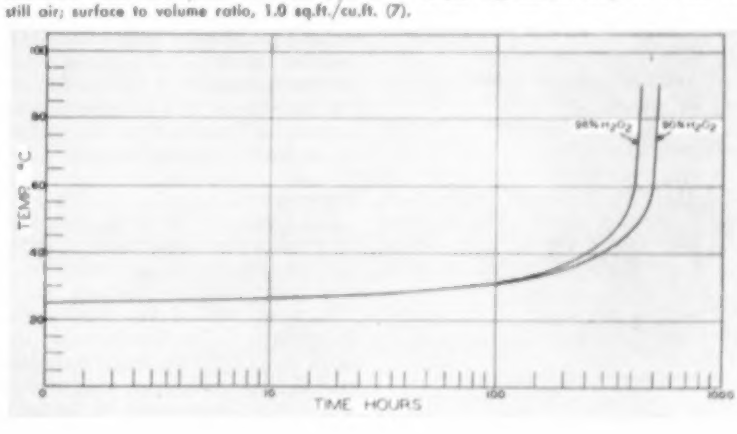
Table 8.—Results of Ambient Temperature Mechanical Shock Sensitivity Tests on 99% and 90% H_2O_2 (5)

Test No.	H_2O_2	Tube dimensions: I.D., in.	Length, in.	Wall thickness, in.	Wt. of charge, g.	Boosters Wt. g.	Boosters spacing cm.	Rate of detonation between stations: 1-2 millisec.	2-3 millisec.	1-3 millisec.	Remarks
1	99%	1	24	.17	398	20.0	40	*	—	—	12 in. of tube recovered
2	"	1	24	.17	385	20.0	40	7,130	—	—	Complete detonation
3	"	1	48	.17	975	20.0	50	*	4,800	—	Complete detonation No spark on No. 1 wire
4	"	1	48	.17	973	20.0	50	6,990	4,630	5,590	Complete detonation
5	"	1	48	.17	978	10.0	50	*	*	*	47 in. of tube recovered
6	90%	1	48	.17	925	20.0	50	*	*	*	All of tube recovered
7	99%	¾	24	.15	247	20.0	40	*	—	—	21 in. of tube recovered
8	"	¾	24	.15	239	20.0	40	*	—	—	16 in. of tube recovered
9	"	¾	48	.15	473	30.0	50	*	*	*	All of tube recovered
10	"	¾	48	.15	486	40.0	50	*	*	*	39 in. of tube recovered
11	"	¾	48	.15	490	40.0	50	1,790	1,970	1,880	Large pieces recovered
12	"	½	24	.14	131	20.0	40	*	—	—	17 in. of tube recovered
13	"	½	24	.14	135	20.0	40	*	—	—	21 in. of tube recovered
14	"	½	48	.14	273	20.0	50	1,570	1,310	1,430	Both ends of tube fragmented. Center portion intact.
15	"	½	48	.14	264	30.0	50	2,080	1,960	2,020	Large pieces recovered
16	"	½	48	.14	270	40.0	50	1,540	1,060	1,260	Large pieces recovered

* No spark record

Tests carried out by the U.S. Bureau of Mines, Bruceton, Pa.

Fig. 10. Calculated self-heating curves for 98% and 90% H_2O_2 in large, pure aluminum storage container. Basis: decomposition rate 50%/yr. at 77° F. (25° C.); ambient temp. 77° F. (25° C.), still air; surface to volume ratio, 1.0 sq.ft./cu.ft. (7).



organization and functions of an OPERATIONS ANALYSIS GROUP

Here is a case study of how one operations analysis group is organized, how it fits into the corporate structure, what sort of functions it performs, and how these services are utilized.

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Whether Operations Analysis proves to be a passing fancy or a permanent addition to the science of industrial management, it has achieved impressive results in such areas as production scheduling, inventory control, and transportation problems. Can these mathematical techniques be applied with similar effectiveness to the activities and needs of a research and development organization?

This new discipline may be loosely defined as the application of mathematical analysis to complex technological and business problems which require a sequence of interdependent decisions to obtain an optimum result. The complex situation may often be represented by a mathematical model which furnishes quantitative estimates of the consequences of possible alternatives, to facilitate the decision-making process.

Although the concept of basing judgment on numerical data is not new, there is one important factor which justifies the current emphasis on these mathematical techniques. This is the recent development of the high-speed electronic data processing machine. Such computers, with a capacity of more than one million operations per second, make light of the computational burden that would have bogged down any operations researcher who had to depend on his log tables and slide rule. These so-called electronic brains offer no relief from the painful process of thinking, but the very act of addressing meaningful questions to the machine can in itself stimulate thinking.

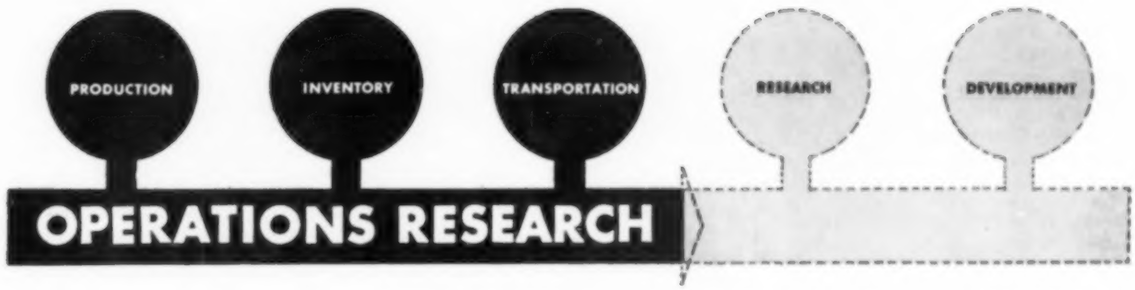
Organization

The Operations Analysis section of the Development Department of Union Carbide Chemicals Company is a staff group which was formed late in 1954 as an arm of the Development Department. The Development Department is a laboratory organization of 400 people concerned with product and process development in the fields of synthetic organic chemicals and resins.

The Operations Analysis group came into being to consolidate and formalize grass roots activities which had been initiated by several individuals in the department and strongly supported by the director of development. The centering of these activities in one group brought together three chemical engineers, two chemists, a physicist, a mathematician, a statistician, and four technicians. All members of the group have a fair background in mathematics and have been exposed to a variety of computer training programs. It also has been found helpful to engage the services of consultants in the field of operations analysis and in the field of experimental design. These contacts were not only stimulating but invoked the principle of learning by doing. Expansion of this section is predicated upon demonstrated demand for its services, and today the backlog of work in many of its functions justifies a doubling of the staff.

In the realm of hardware the progression has been from an IBM 602A accounting machine, to a CPC, to a 650. A Ramac 650 is on order for local use, and an IBM 709 will become available late in 1958 at a Westchester location. This last-named machine will serve the corporation as a whole, but already work is being done on a problem which will require this advanced computer.

The position of this group in the Development Department has an important bearing on the nature of the problems handled. Its primary role is to facilitate, augment, and evaluate the technical work of the department. This is done largely through such functions as experimental design, statistical analysis of data, engineering analysis, electronic data processing, and technical computation. The realm of operations analysis, on the other hand, is primarily concerned with technological and business problems, which



are generally of company-wide scope. Interest here is centered on the development of mathematical models and machine solutions which are then implemented by the appropriate operating departments. This corresponds to the traditional role of the Development Department in developing new processes which are then graduated from the laboratory to the plant.

Functions

The work of the Operations Analysis section may thus be compartmented in terms of distinctive functions which are the primary responsibility of separate groups within the section.

DEVELOPMENT OF OPERATIONS RESEARCH TECHNIQUES

This group is principally concerned with the development of mathematical models and machine programs which will be useful in the solution of company-wide problems that are particularly amenable to the Operations Analysis approach. The group is also concerned with the application of these models to actual operating problems so that their utility can be more widely assessed and appreciated. Inasmuch as solutions of this type are likely to impinge on managerial prerogatives, there can be considerable sensitivity or even resistance toward accepting ready-made solutions from a staff group, no matter how expert or objective. For this reason it was found desirable to tackle actual problems by forming Operations Analysis teams of four or five members, including representatives from both the Operations Analysis group and from the departments that will be involved in implementing the solution. The efforts of these Operations Analysis teams are coordinated by a company-wide Operations Analysis Steering Committee on which most major departments are represented. This committee helps to select suitable problems, appoints the working teams, arranges for effective implementation, and undertakes to appraise the results.

By way of illustration, two broad problems may be mentioned on which the Operations Analysis group has worked. The first is the Monitoring problem, as applied to the monitoring of product quality, of manufacturing costs, and of financial return. The objective here is to compare performance data statistically against preestablished or continuously adjusted standards to single out for special attention those products and processes which violate the established norms. Management can then concentrate its efforts on the exceptional cases. After a period of pilot operation of the monitoring system including the issuance of model reports, it was turned over to those groups which are directly concerned with its maintenance and use. The monitoring of product quality is now administered by the Quality Control Laboratory, the monitoring of manufacturing costs by the local plant operating departments, and the monitoring of profitability by the financial control manager of the company.

Another and far more ambitious project is the Assignment problem: for any given sales pattern of product mix and customer distribution, utilize the available raw materials, the existing production and storage facilities, and the appropriate transportation means so as to maximize net income, not for any given plant but for the company as a whole. The complexity of this problem results from the fact that over 50 different chemicals must be included to represent 90 per cent of the company's sales volume, that production facilities are located in seven different plants, and that over 50 customer areas should be differentiated. Decisions are now being made by the seat of pants well worn with experience, but the cost of suboptimum allocations is not known. It is not yet clear that the over-all situation can be encompassed by a workable model, but good progress has been made with a simplified model which includes five products, five plant locations, and ten customer areas. The principal purpose of this pilot model is to help define the nature of the input data required and the kind of restrictions to be imposed. An indication of the economic incentive to this sort of project is afforded by a current distribution study which forecasts a potential saving of more than a million dollars a year in the distribution and storage costs of but one of our major products.

DESIGN OF EXPERIMENTS AND STATISTICAL ANALYSIS OF DATA

The principal business of the Development Department is to carry out product development, process development, and pilot plant studies. Statistically designed experimentation is not applicable to all types of laboratory projects but, where applicable, it will permit experimental coverage of process variables with approximately half the number of experiments that would be required by the classical approach. Concomitantly, statistical analysis of the data so obtained will permit a more penetrating interpretation of the results, particularly as regards the interaction of variables. Use of this mathematical tool will not prove a remedy for sloppy or unimaginative experimental work. It will, however, call for thoughtful planning before rushing into the laboratory, and it will also afford a measure of the inevitable experimental errors. The experimental designs are furnished as an optional staff service and the experimental groups retain full responsibility over the conduct of the work, the interpretation of the results, and the recommendations for action.

DESIGN OF PROTOTYPE EQUIPMENT: ANALYSIS OF CONVERTER DYNAMICS

In undertaking a major experimental program, the design of the experimental equipment may have an important bear-

ing on the progress of the investigation and the quality of the data. Theoretical chemical engineering calculations based on reaction kinetics (if known) and considerations of heat release and mass transfer may permit prediction of the converter dynamics. This in turn may facilitate the selection of propitious converter geometry and cycle characteristics before actual experimentation is begun.

The analysis of such hypothetical converters, which might be termed mathematical experimentation or engineering analysis, is importantly facilitated by machine computation. Its effectiveness is heavily dependent upon the availability of sound primary data, and for this reason it can often best be applied to data derived from well-executed experimental designs. For the simulation of reaction systems that have been reduced to differential equations, the group has access to an analog computer.

ECONOMIC APPRAISAL OF PROPOSED PROCESSES

In planning research and development projects, it is frequently necessary to choose among three or four alternative routes to a desired new product. Not only should experimental effort be concentrated on the most promising alternative, but it is desirable to assess the magnitude of the expected pay-off in order to determine how ambitious an experimental program may be justified.

In development work, as distinguished from exploratory research, the economics of a proposed chemical process can generally be estimated with sufficient accuracy to afford a meaningful guide to its profit potential. The preparation of such rough appraisals is rapid and reliable in the hands of specialists, but would be time consuming and of questionable validity if imposed on the experimental groups.

One application of this type of preliminary economic appraisal is to facilitate project selection. If a measure of the incremental return from a project is divided by the estimated cost of the necessary experimental work and tempered by the probability of success, the resulting quotient, termed the project potential, may be employed as a rough index to the relative attractiveness of proposed experimental projects. The measure of the pay-off will vary with the type of project. For a new product or process it may be the incremental return on investment (above that realizable from plant expansions requiring no development work) calculated for an arbitrary number of years, such as five; for a process improvement resulting in higher efficiencies or productivities, it may be the actual savings in raw material and labor costs projected for a limited number of years; for a pilot-plant operation, it may be the estimated savings attributable to more precise design and more rapid attainment of full production. This activity fits logically into the Operations Analysis section, although little computer hardware is required beyond a desk calculator and a 10-inch slide rule.

MANAGEMENT OF TECHNICAL INFORMATION

In order to prepare a preliminary economic appraisal, it is sometimes necessary to postulate yields, reaction conditions, and processing procedures. In the absence of exploratory laboratory work on a given synthesis, reasonable assumptions may often be predicated on information gleaned from the technical journals and the patent literature. Similarly, before undertaking experimental work, it is important to know what has been done both inside and outside company laboratories, if duplication is to be avoided. Hence, rapid, systematic, and comprehensive access to the wealth of information in scientific journals, the patent literature, and internal reports is of major concern to a laboratory organization.

A study of the Literature Problem by the Operations Analysis group has indicated that the use of microfilm storage and high-speed automatic searching devices (such as the Eastman Minicard system) though technically feasible, is still some years from commercial reality. Until the scientific societies and the U. S. Patent Office undertake to publish their abstracts and indexes on IBM cards or Minicards, the task of adapting this information to mechanical retrieval appears too forbidding for any private agency to countenance. For the present, the technical and patent literature must be searched manually in the old-fashioned way. Selective coverage may be provided through the circulation of privately prepared monthly bulletins of pertinent literature and patent abstracts.

The problem of processing the internal literature is much more tractable although it requires coordination among the various departments that generate technical information and numerical data. In the case of a large chemical company such as Union Carbide Corporation, the internal data may represent the fruits of an annual experimental expenditure in excess of fifty million dollars. These are contained in a variety of publications from more than a score of company laboratories. A punch-card system has been developed for the indexing and mechanical searching of technical information based on a superimposed random code. This system, which can handle up to one hundred thousand chemical names and one hundred thousand concept terms is being applied to all internal reports and certain selected patents. It merely identifies and locates the document containing the desired information, which must then be obtained from the library files.

In addition, the Operations Analysis Steering Committee has recognized the need for a central data bank. This will provide systematic storage and machine retrieval of operating, marketing, and financial data which represent the week-by-week and month-by-month operating experience of the company as a whole. These data form the basis upon which all future operational analyses must depend.

Electronic Data Processing and Computer Applications

This mathematical group is primarily a service arm to the other groups in the Operations Analysis section. It formulates problems in terms of specific methods of numerical analysis amenable to machine solution, writes machine programs, debugs them, and supervises machine operations. It also offers this service to other departments upon request.

A recent assignment for this group is the evaluation of digital data processing systems for the automatic scanning, logging, and reduction of pilot plant data. The process computer receives the digital equivalent of analog signals representing temperatures, pressures, feed-, product-, and cycle-flows, mass spectrometer scans, vapor fractometer scans, continuous gas analyses, and the like. It logs them, in digital form; compares the readings against predetermined control limits; signals violations of critical limits; and computes from the primary data such reduced values as conversions, yields, productivities, material balances, and heat balances. This type of advanced instrumentation, which places the computer in the pilot plant, will greatly facilitate the operation of complex experimental systems by permitting the closer control of process variables, the rapid reduction of raw data, and the faithful logging of all readings at predetermined intervals.

One computer manufacturer is proposing the use of a stored program, based on a systems analysis of the process, which would permit a closing of the loop by having the computer feed back analog signals to reset conventional control instruments. With a control computer of adequate memory, it would be possible to store a complete experimental program of perhaps sixty-four statistically designed experiments, and run through the entire program as fast as the establishment of steady-state equilibrium conditions and the logging of data for a fixed test period will permit. The computer itself will decide when to start the collection of product and when to proceed to the next set of conditions. It remains to be demonstrated whether automation and experimentation will prove compatible.

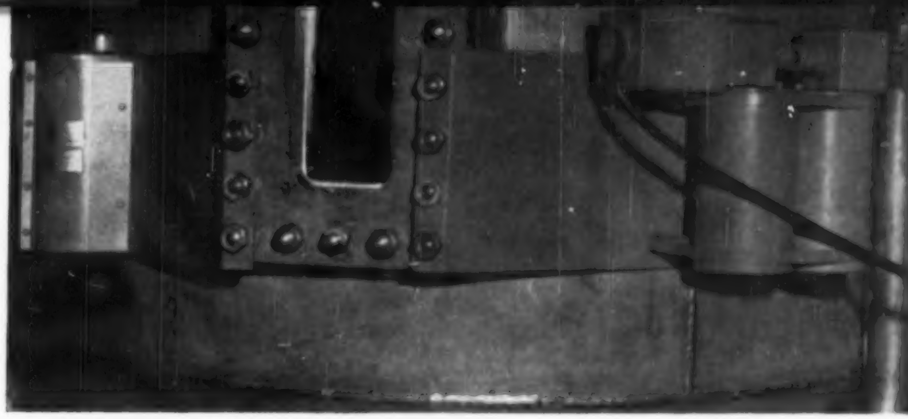


Fig. 3. Ohmart source holder and dual measuring cell installation on expanded column disengagement section.

GAMMA DENSITY CONTROLS EXTRACTION COLUMN

Gamma absorption density gauging can monitor both the organic extract and the aqueous raffinate and can control column feed rates to maintain normal steady-state operation in a liquid-liquid uranium extraction process.

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The present emphasis on the production of uranium from uranium-bearing ores and ore concentrates has led to rapid technological advancements in the field of large-scale metal recovery and purification. Most of the separation methods developed to date involve liquid-solid or liquid-liquid extraction systems. These systems are for the most part sensitive to fluctuations in process stream flow rates and component concentrations and therefore are more adaptable to continuous operation. The combination of process sensitivity and round-the-clock operation makes the use of automatic analytical and control instrumentation to reduce manpower requirements and production costs most desirable. The uranium extraction process in operation at the Feed Materials Production Center (FMPC) located at Fernald, Ohio, (*1*) falls into this category.

The objective of the present study was to determine the feasibility of a gamma radiation gauge for measuring the fluid density and ultimately the uranium concentration in a multi-component, two-phase, liquid-liquid extraction system. Three separate applications of this type of instrumentation were investigated, two being directly concerned with operational control of an extraction column, and the third being the application of the gamma gauge to the study of basic countercurrent extraction variables. The present paper deals with some preliminary studies which have been conducted at the FMPC, Fernald, to determine the feasibility of this type of instrumentation for extraction column control.

Extraction principles involved and types of contactors used have been presented in detail (*1, 6, 4, 3*) and are beyond the scope of this paper. Hence, only a brief description of the particular column and instrumentation used in these studies will be included. In order to understand many of the criteria included in this feasibility study, the following details must be appreciated.

Details of Operation

The extraction unit is a vertical column, packed with parallel perforated plates, closely spaced at regular intervals. An organic phase of lower density, containing a reagent which preferentially extracts the uranium values from the aqueous feed stream, is introduced at the bottom and passes up the column countercurrently to the more dense aqueous phase. In addition to the countercurrent flow, the combined phases are moved up and down in the column with a pulsing motion which results in intermittent mixing of the phases at the plate surfaces by forcing the liquids through the plate holes and allowing separation of the phases in the zones between the plates. This results in essentially a series of countercurrent flow mixer-settlers, stacked one above the other. Expanded sections at the top and bottom of the plated portion of the column permit final separation of the organic and aqueous phases before they leave the unit. The organic product stream leaving the column contains the uranium, and the aqueous waste stream is essentially free of uranium.

During normal column operation, the aqueous feed stream uranium concentration and the flow rates of the aqueous and organic streams are adjusted to yield a maximum uranium concentration in the organic product stream with an essentially uranium-depleted aqueous waste (raffinate) stream. This situation

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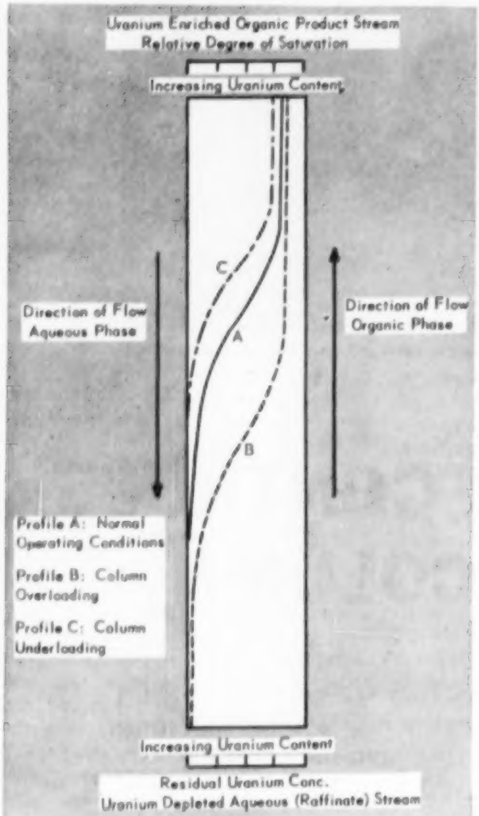


Fig. 1. Variation in extraction column uranium concentration or total fluid density profile under varying operating conditions.

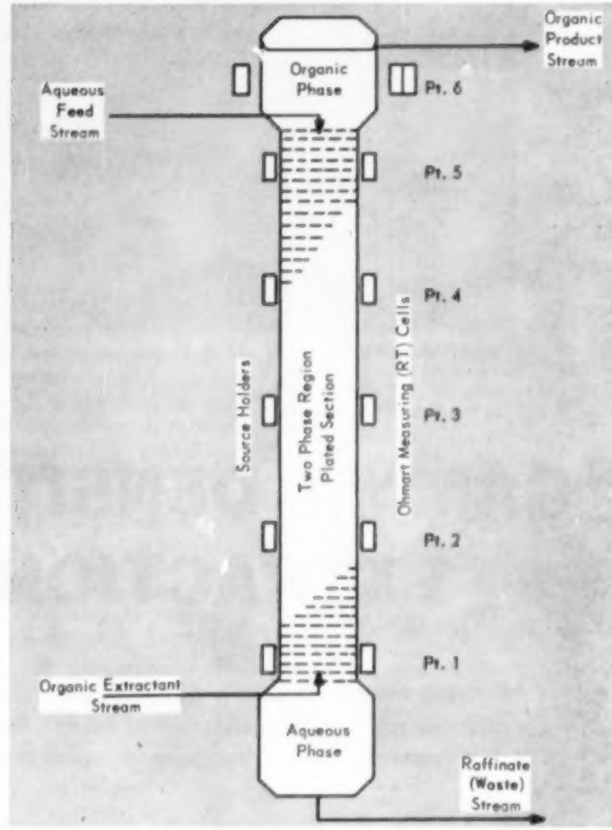


Fig. 2. Extraction column with experimental Ohmart density measurement installation.

is presented diagrammatically by profile *A*, (Figure 1). A reduction in the feed stream uranium concentration or flow rate, other conditions held constant, will result in column underloading (profile *C*, Figure 1). Under these conditions a reduction in column productivity and product purity results. The reverse of these conditions, or column overloading, occurs when the feed stream uranium concentration or flow rate exceeds the normal and results in excessive uranium loss through the raffinate stream and/or column flooding (profile *B*, Figure 1). It is this latter abnormal operating condition which must be avoided in order to maintain efficient column performance and maximum productivity of a high purity material.

Conventional methods of studying column behavior rely on physically sampling and chemically analyzing the end streams and, in some cases, withdrawing samples at intermediate points along the column. These are time consuming and, in the case of the intermediate column sampling, generally yield results which do not reflect true equilibrium conditions (*5*).

The physical nature of the extraction system, with respect to its sensitivity toward disturbance of the stream flows and the corrosive and erosive properties of the reagents employed, limit the type of instrumentation that can be used. Ideal instrumentation for this system would incorporate the following features:

- **Continuous and instantaneous density measurement**
- **Elimination of the necessity of withdrawing liquid samples from the column thereby avoiding disturbing the true operating conditions existing in the system**
- **A location external to the fluid system**
- **Relative insensitivity to power fluctuations**
- **Equipment—compact and rugged**
- **Ability to measure density with an accuracy of ±2%.**

The gamma radiation density measuring instrument, manufactured by the Ohmart Corporation, was selected for evaluation since it appeared to most nearly meet the desired criteria as outlined. In addition, the instrument possesses the following characteristics:

- **It could be easily installed at any desired location without modification of the existing extraction equipment.**
- **Adequate radiation shielding is an integral part of the instrument.**
- **The instrument (with the exception of the recorder) operates completely independent of an external power source.**

A technical discussion of the basic principles underlying the operation of the Ohmart density gauge has been published and is available (*2*).

Principles of Ohmart Gauge

A six-point density measuring system was designed by the Ohmart Corporation for installation on an experimental extraction column (see Figure 2). One measuring circuit was installed on the upper expanded disengagement section to monitor the density of the deentrained organic product stream (Figure 3). The other five units were placed at intervals along the plated length of the column to measure the density of the two-phase system at these points and thereby give a density profile of the system; this arrangement thus provides a useful tool for observing column operating conditions as revealed in Figure 1.

In addition, the two lower measuring points were employed in a balanced circuit to detect any differences between the densities of the contained fluid at the two column locations. This was accomplished by reversing the polarity of one of the cells and adjusting the individual measuring cell circuits by means of the compensating cells to give a zero resultant current when the uranium concentrations at the two points were equal and essentially zero. On the assumption of a variation in density at either point to be due to a change in uranium concentration only (any change in the concentration of

the other components contributing relatively little to the fluid density), then any movement of the uranium profile down the column due to an overloading of the extraction system would result in an increase in uranium concentration and therefore an increase in density at the upper point. This in turn would cause a decrease in current from the upper cell and an unbalancing of the circuit with a resultant flow of current. The current can be used to control a throttling valve on the feed stream to return the system to operational equilibrium.

Each measuring point consisted of a 60 mc. cesium-137 radiation source enclosed in a lead-shielded source holder and mounted externally on the column wall. Cesium was used as a radiation source because of its long half life (33 years) and the fact that it emits relatively low-energy gamma rays. The long half life of the isotope permits continuous, stable operation over long periods of time without the necessity of frequent shutdowns for recalibration. Low-energy gamma rays from cesium-137 are more readily absorbed than those of cobalt-60 and therefore give the degree of sensitivity required. A scaled-down pipe filled with uranyl nitrate solution was used to verify the quantity required and equally important to demonstrate that the absorption was sufficiently linear with density over the concentration range involved. The quantity of isotope was chosen so that the radiation transmitted through the physical system to the measuring cell would give a minimum of 3×10^{-10} amp. current output, which is required to attain a density measurement precision of 2% of full scale. The source size is therefore dependent on the geometry and material of construction of the container and the density of the contained material. Each source holder contains approximately 60 lb. of lead distributed to give a minimum of 1¾ in. of shielding.

Diametrically opposite to the source holder, the Ohmart (RT) measuring cell was mounted in a like manner. The cells were connected by coaxial cable (nonmicrophonic) through a modified Beckman Model 1710 multiswitch and a Beckman Model V micromicroammeter to a Brown strip chart, six-point recorder. In order to increase the amplifier sensitivity so that the change in the field intensity with change in density of the fluid system could be made to utilize 100% of full scale, each measuring cell was connected in parallel with an Ohmart compensating cell of opposite polarity (*2*). This null system provides a method of scale expansion over the entire range of observed field intensities. The compensating cells used 250 μc of radium as the radiation source.

Radium was chosen for economical reasons at a slight sacrifice of long-term stability. For maximum stability, the same source material should be used in both the measuring cells and the compensating cells. In this way the effect of different rates of decay of the two source materials will not gradually introduce an error in the density measurements thereby requiring recalibration. A diagram of the Ohmart density measurement system is shown in Figure 4.

Since each multiswitch unit has provisions for only four circuits, two units wired in series through one of the available positions were used to control the six points. The system permitted either automatic or manual selection of the points to be measured. The recorder automatically and consecutively selected the point to be measured at 30-sec. intervals; thus each point was measured every 3 min. All the components other than the primary sources and measuring cells were rack-mounted as shown in Figure 5.

The Ohmart (Model RT) measuring cell was chosen as the sensing instrument rather than an ionization chamber or Geiger counter for a number of reasons. The Ohmart cell gives a useful signal to noise ratio ten to one hundred fold greater than the other instrument; thus, the recording of small variations in density over a large density range, equivalent to small changes in uranium concentration in the extraction column can be recorded. Each measuring cell scans a vertical column height of approximately 6 in. which includes a number of plates, thereby eliminating the effect of the pulsing action in the column and giving an average density over this span.

No external source of current is required for either the measuring or compensating cells; the instrument is thus independent of line current drift or power failures. This is of twofold importance first, since it increases the instrument's stability, thereby reducing the frequency of operational shutdowns for recalibration, and second, because it permits its installation in hazardous areas without explosion-proofing any of the components except the recorder. The current generated by the measuring cell is of the order of micromicroamperes and the maximum voltage obtained is one volt. A preamplifier is not required at the cell location; the signal is carried up to several hundred feet through coaxial cable directly to the amplifier.

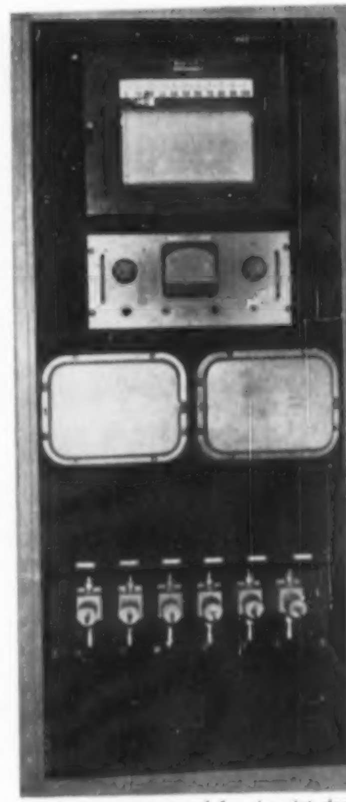
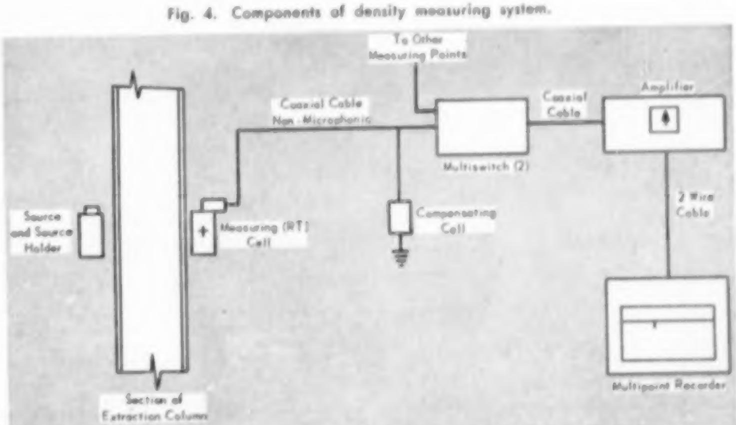


Fig. 5. Instrument panel for six-point density measuring system.

After the type and quantity of isotope to give the desired accuracy and precision were established and the construction and installation completed, the instrument

Fig. 4. Components of density measuring system.



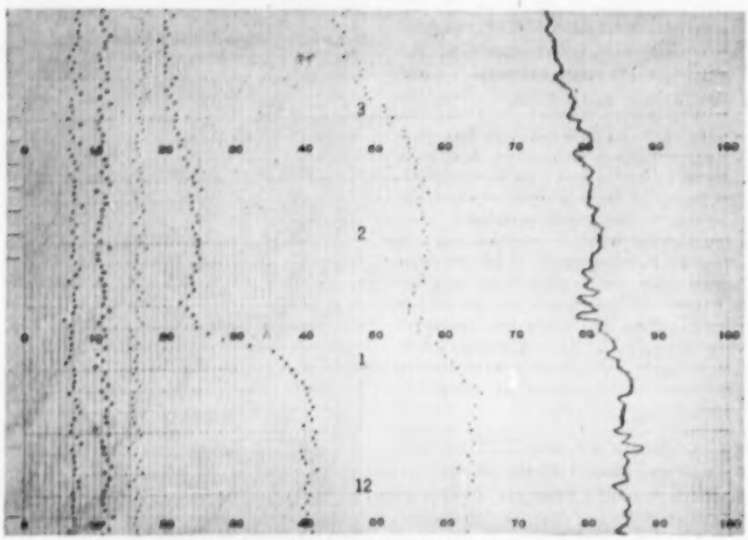


Fig. 6. Extraction column density profile (section of strip chart recording).

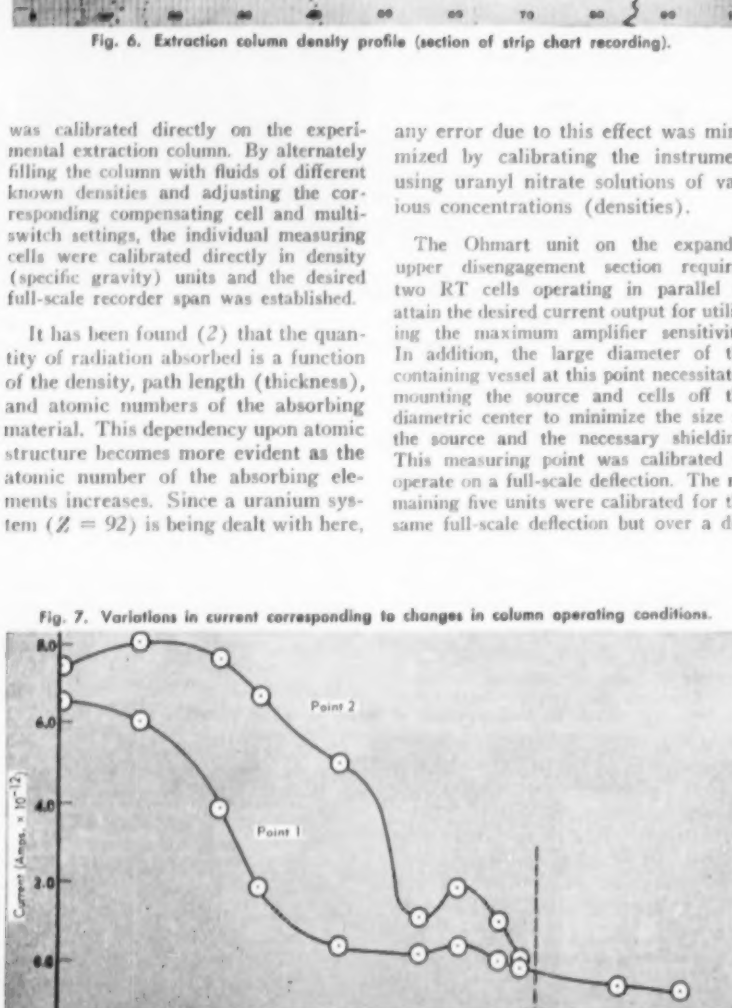
was calibrated directly on the experimental extraction column. By alternately filling the column with fluids of different known densities and adjusting the corresponding compensating cell and multiswitch settings, the individual measuring cells were calibrated directly in density (specific gravity) units and the desired full-scale recorder span was established.

It has been found (*2*) that the quantity of radiation absorbed is a function of the density, path length (thickness), and atomic numbers of the absorbing material. This dependency upon atomic structure becomes more evident as the atomic number of the absorbing elements increases. Since a uranium system ($Z = 92$) is being dealt with here, any error due to this effect was minimized by calibrating the instrument using uranyl nitrate solutions of various concentrations (densities).

The Ohmart unit on the expanded upper disengagement section required two RT cells operating in parallel to attain the desired current output for utilizing the maximum amplifier sensitivity. In addition, the large diameter of the containing vessel at this point necessitated mounting the source and cells off the diametric center to minimize the size of the source and the necessary shielding. This measuring point was calibrated to operate on a full-scale deflection. The remaining five units were calibrated for the same full-scale deflection but over a different absolute density range. The difference in density range was dictated by the fact that the uppermost point measured the density of the organic phase only, whereas the other points measured the density of the two-phase system.

A more complex experimental technique was required to calibrate the two cells on the lower part of the column to be used for raffinate control. Both cells (Figure 2, Points 1 and 2) were located at points such that the total uranium concentration (in both phases) normally exceeded that permitted in the raffinate stream. The current from each cell was read independently rather than simultaneously by appropriate positioning of the selector switch. In order to permit an independent check on the system, each cell was placed adjacent to a liquid sampling stopcock so that samples of the liquid could be withdrawn at the same time current readings were taken and directly analyzed for their uranium content.

Fig. 7. Variations in current corresponding to changes in column operating conditions.



With the column operating under normal conditions, as indicated by the fact that raffinate samples showed a negligible uranium content by fluorimetric analysis, both cell circuits were arbitrarily set to give a zero scale deflection by proper adjustment of the compensating cells. The difference in current between the two points was therefore zero.

The aqueous and organic stream flow rates were then varied stepwise so as to upset the column conditions in the direction that would cause the uranium concentration gradient to move down the column. After each change, the system was allowed to reach steady state and current readings and liquid samples were taken.

The cell installed on the top disengagement section to monitor the density of the product stream gave excellent results with respect to stability, sensitivity, and accuracy. It operated efficiently over a full-scale range with a maximum noise level of 2% of full scale.

Difficulty was encountered when attempts were made to calibrate directly the recorder-scale in uranium concentration units.

Abnormal variations in product stream temperature amounting to as much as 20° C. over a 5-min. time interval were observed. These produced up to 14% of full-scale deflection. Efforts are being made either to control the temperature of the extraction column inlet streams more closely or to maintain a temperature control on the product stream at the density measuring point.

Results of the test program indicate the feasibility of the Ohmart gamma gauge for product stream density and uranium concentration monitoring.

The series of gauges mounted along the plated section of the column presented a continuous density profile of the system. Changes in the profile with changes in stream flow rates and ratios were recorded instantaneously. A typical strip chart recording of the system profile is shown in Figure 6.

The test results also indicate the feasibility of using the two-point measuring system to control extraction column overloading.

Under overloading conditions, two density gauges located 5 ft. apart at the lower end of the plated column detected a uranium concentration differential for which the instrumentation as described gave a resultant current differential of 0.25 $\mu\mu$amp. No secondary current fluctuations due to the pulsing action in the column were observed. A plot of current output with respect to time, as the column was brought from an overloaded condition with uranium loss in the raffinate stream to normal operating conditions, is shown in Figure 7. The minor density variation due to the presence of suspended solids and soluble components other than uranium were not sufficiently great to mask the primary density variations due to uranium concentration changes. On the basis of these preliminary test results, it appears that this type of instrumentation can easily be adapted not only to detect potential uranium losses in the raffinate stream, but also to control the feed stream flow so as to avoid any excessive loss.

Summarizing the results of these preliminary investigations into the feasibility of employing gamma radiation density measurement to the liquid-liquid extraction system as in operation at Fernald, Ohio, one concludes that the instrumentation is capable of (1) continuously and accurately monitoring the density and uranium concentration of organic product stream from the extraction column, and (2) adapting to control the feed stream flow rate so as to maintain normal steady-state column operation.

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To be presented at A.I.Ch.E. meeting, Chicago, Illinois.

WHAT'S IN

Symposium Series Volume 53

(Number 20, 1957—Liquid Metals Technology—Part 1)*

High-temperature Loop for Circulating Liquid Metals

R. W. Fisher and G. R. Winders

The purpose of the experiments was to circulate potential liquid metal reactor fuels and breeder blankets at temperatures approaching 1,000° C. and to investigate the fabrication methods and corrosion problems which eliminate many of the better known container materials.

The experiments indicate that tantalum metal, when adequately protected by Inconel in a helium atmosphere, is a satisfactory container material for circulating molten magnesium-thorium and bismuth-uranium alloys. The heating transformer was satisfactory as a method of maintaining high temperatures for prolonged periods. The two-pole linear electromagnetic pump is quite satisfactory for pumping alloys of this type where low rates of flow are desired. The pump is compact and has a calculated efficiency when pumping bismuth metal of approximately 0.12%.

Fractional Precipitation Processes for Liquid Metal Fuels

Robert J. Teitel

Several liquid-metal fuels based upon uranium-bismuth, uranium-lead-bismuth, uranium-lead-tin, and uranium-lead-bismuth-tin alloy systems have been proposed for reactor design. Experimental data on the distribution of rare-earth tracers between precipitated uranium intermetallic compounds and their liquid phases are reported and discussed.

A dispersion of USn_x in lead-bismuth-tin liquid has been tested by this process and was found to be satisfactory. A process for this fuel has been proposed.

A discussion of other fuels and breeder systems which might employ precipitation processes has been presented and there are promising possibilities. However, many data are needed to evaluate these other processes.

Thermal Conductivity of Metals

C. T. Ewing, B. E. Walker, J. A. Grand, and R. R. Miller

A general equation for metals based on the concept of electronic and molecular conduction in metals has been developed to replace the Wiedemann-Franz relationship, which has been found inadequate for a general correlation of metals. The development of this equation and its application in the prediction of thermal-conductivity values for metals are discussed. The molecular heat transfer in metals is shown to be similar to that in nonconductors by an application of the equation to simple organic liquids.

It has been shown that for any metal or alloy (other than a semiconductor), whether liquid or solid, the thermal conductivity can normally be estimated within 5 or 10% from the equation presented, if reliable resistivity values are available. The over-all average deviation for all the metals correlated was 5%.

As reliable values for thermal and electrical properties are measured, more precise correlations, similar to the one described, should permit a better understanding of the liquid and solid states for metals. It is felt, therefore, that there is a definite need for further reliable measurements to be made on both thermal and electrical conductivities.

Sampling and Analysis for Impurities in Liquid Sodium Systems

J. R. Humphreys, Jr.

The sampler developed at Argonne National Laboratory is described. A representative sodium sample is drawn into a metal-foil-lined metal receiver. Vacuum distillation removes the sodium from its nonvolatile impurities directly in the sampler and the residue is analyzed by standard radiological or chemical methods. This method of impurity separation is also applicable to other liquid metal systems, such as mercury and cesium. The sampler is easily adaptable to remote operation for use with radioactive systems.

Manufacture and Availability of the Alkali Metals

Marshall Sittig

Manufacturing processes for the various alkali metals are reviewed and some brief historical background given as an introduction to a general comparison of thermochemical and electrolytic processes.

Future trends for the alkali metals are all upward, particularly in the case of sodium and lithium.

The low price of sodium combined with the increased knowledge of sodium handling techniques available as a result of atomic energy work have made the metal very attractive to industry. This has resulted in the change-over of the titanium industry from magnesium to sodium as the preferred reducing agent and may result in wider use of sodium in other industries.

Potassium uses continue to grow slowly, with emphasis on the low-melting sodium-potassium alloy as a versatile heat transfer medium.

* *$4.25 to nonmembers; $3.25 to members; 115 pages. Obtainable from offices of A.I.Ch.E. New York.*

An industrial engineering approach to estimating

DIRECT OPERATING LABOR REQUIREMENT for CHEMICAL PROCESSES

What constitutes a fair day's output or what an individual can actually accomplish without undue or injurious physical or mental strain is a manpower problem in the chemical manufacturing industry which, because of its wide variations, offers an extraordinary challenge to the techniques of industrial engineering.

Tom B. Haines
Dow Chemical Company, Midland, Michigan

This is another article in a series on direct operating labor costs introduced by John Happel in the October issue, page 465. The final article in this series will appear in the December issue.

Engineers in general, and chemical engineers in particular, at times become so interested in equipment, its design, function, maintenance, and the processes employing it that they tend to forget the human factor, namely manpower; at other times they completely overlook manpower's relationship to equipment operation, costs, profits, and the fact that for a given chemical process there is but one efficient manpower requirement. Either over- or undermanning makes for a lowered efficiency.

Manpower is also important because it is a cost. Direct operating labor cost is an important part of total production cost not only as a specific item but also because of its effect upon related and indirect expense. It has been stated that direct labor cost varies from 4 to 30 per cent or more of total production cost. In addition, related expenses and fringe items such as vacation and pension benefits, social security taxes, holiday pay, insurance programs, supervisory costs, rate and payroll functions, lunch- and locker-room facilities, company required clothing, and personnel supplies are a direct function of labor cost. Finally, indirect or so called "burden" expenses such as medical, transportation, parking, and telephone facilities; maintenance of personnel, labor relations, plant protection, safety, and educational departments; and other less tangible services vary with direct labor and account for a goodly portion of total production cost.

Importance of manpower and its cost are emphasized because frequently one thinks only of the direct hourly labor rate rather than the whole true cost of adding one man. Therefore, it is advisable in estimating direct labor requirement, to make use of the best experience and information available in order to keep these costs at a minimum.

However, information and data concerning actual labor requirement for chemical processes is rather scarce, hence for the most part such estimations are arrived at through the previous experiences of management and supervision. This procedure leaves the inexperienced engineer "hanging on the ropes" since he has no wealth of experience from which to draw.

An attempt to overcome this problem and also to augment the experience approach has been made by applying time study techniques and methods of the industrial engineering field in the estimation of direct operating labor requirement. "Elemental Standard Time Values," arrived at

through time study, are used to build up the amount of work necessary to carry out chemical processes.

Time Study Technique

What is Time Study? Time study is the analysis of a given operation to determine the elements of work required to perform it, the order in which these elements should occur, and the time which is required to perform them effectively.

All work may be resolved into terms that are more or less basic. Time study looks at a job not as a single quantity, but rather as a series of elemental operations. When a job is resolved into its component parts or elements, each element then may be considered separately and the study of the job thus becomes a series of fairly simple problems. Furthermore, when a number of different but similar jobs are reduced to their elements, it is found that several elements are common to all jobs. Certain elements vary with every job, but the variation is in degree rather than in kind and therefore even variable elements have repetitive characteristics.

Time studies are made by an observer using a stop watch. At the completion of each work element the watch is read, the element recorded, and performance rated. Performance rating is a procedure in which judgment must be employed and which has as its purpose the adjustment of observed time values to correspond more closely to the time which is deemed to be reasonable and fair for doing the work element. The adjusted time thus obtained is known as normal time and is the time required by a qualified workman, working at a pace which is ordinarily used by workmen under capable supervision, to complete an operation element when following the prescribed method.

To this normal time is added a fatigue and personal allowance which is usually applied as a percentage of the normal time. This allowance is actually time included to permit the worker to attend to personal necessities and to recuperate from the physical and/or mental weariness brought about by doing the work included in the element.

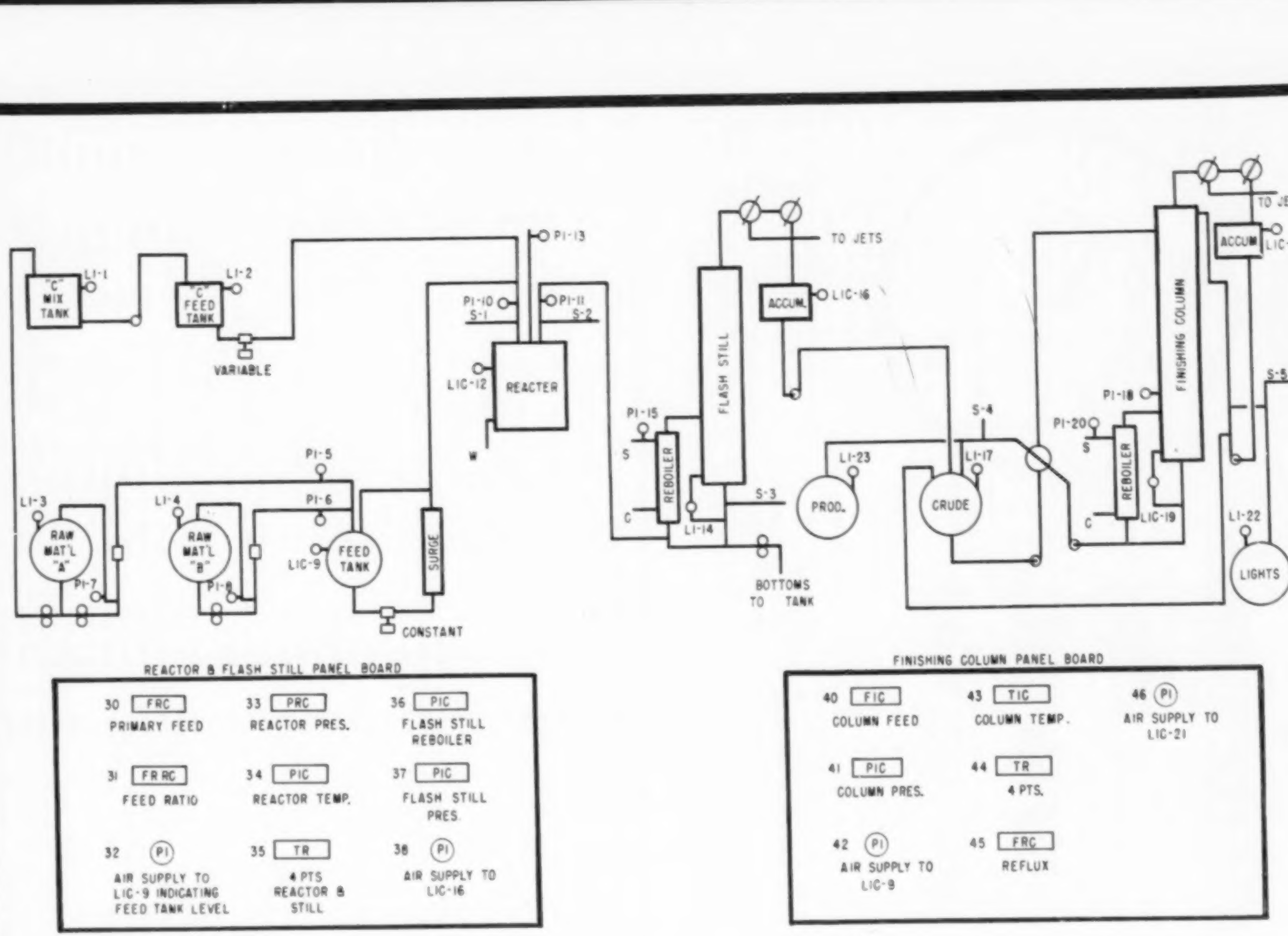
The total time thus obtained is called "Standard Time" and is the time required to do the work while experiencing normal personal necessity and fatigue requirements. If this standard time is for a particular elemental work component, it is called an "Elemental Standard Time Value."

Elemental Standard Time Values

In the observation and preparation of time studies of many existing jobs, elemental standard time values for many different work elements have been determined, and their values have been established with the use of well-known industrial engineering methods and practices. However, they are specifically for Dow's general operating procedures and conditions and are also controlled by the company's concepts and judgment on normal work time and fatigue effects. These values are modified or changed as required. For

Table 1.—Elemental Standard Time Values

Elemental work component	Std. min.	Per unit	*Elemental work component*	Std. min.	Per unit
Walk	.458	100 ft.	Get or away wrench	.100	Each time
Walk downstairs	.100	10 stairs	Tunk valve	.158	Each time
Walk upstairs	.122	10 stairs	Dism. air line to control valve	.240	Each time
Open or close man el. gate	.044	Each time	Air shock control valve	.269	Each time
Wait for man el.	.072	Wait	Unbolt screen from feed line	1.420	Each time
On or off man el.	.033	Each time	Clean screen	1.100	Each time
Ride man el.	.163	10 ft.	Replace screen in line	1.030	Each time
Check PIC, PRC or FRC	.088	Check	Wipe off wrench	.078	Each time
Check FrRC	.110	Check	Pick up or replace grease gun	.071	Each time
Check sight GL or LI	.099	Check	Grease plugcock	.250	Plugcock
Check manometer	.154	Check	Wipe-off grease gun	.094	Each time
Check PI or TR	.044	Check	On or off switch	.033	Each time
Get or aside data board	.050	Each time	Switch filling tank	.750	Each time
Record instr. reading	.099	Recording	Remove recorder chart from box	.140	Chart
Check pump	.100	Check	Note date and code No. on chart	.222	Chart
Check stuck control valve	.047	Check	Open case, remove old chart	.160	Chart
Adjust variable flow pump	2.830	Each time	Position new chart, close case	.490	Chart
Adjust control instrument	.330	Each time	Set old charts in rack	.100	Each time
Adjust pump packing	.091	Each time	Get or aside ink bottle	.050	Each time
Attr. to filling feed tank	1.330	Filling	Ink instrument pen	.189	Pen
Attn. to filling mix tank	2.140	Filling	Notify fore. of oper. difficulties	2.600	Each time
Attn. to drain sludge fr. mix tank	.430	Draining	Get or aside bag cutter (Sheath)	.072	Each time
Attn. to pumping out flash still	2.500	Pump out	Cut bag open	.196	Bag
Arrange by-pass valves (4)	.330	Each time	Dump 50 lb. bag into mix tank	.350	Bag
Open or close plugcock	.091	Each time	Make titration	2.050	Each time
Open or close hand valve (Up to 2½ in.)	.143	Each time	Take sp. gr.	2.740	Each time
Open or close sample line valve	.057	Each time	Run Distillation No. 1	3.980	Each time
Open or close cabinet	.062	Each time	Run Distillation No. 2	5.060	Each time
Pick up sample carrier	.055	Pick up	Check consistency	1.210	Each time
Remove graduate from carrier	.066	Each time	General area check—open area	.121	Check
Flush graduate	.0'9	Each time	General area check—normal area	.242	Check
Draw sample	.078	Each time	General area check—congested area	.418	Check
Set full graduate in carrier	.088	Each time			



CHEMICAL PROCESS FLOWSHEET

(Figure 1)

Table 2.—Analysis of Checks and Actions

Control point		Check frequency/shift: read & record	Check frequency/shift: check	Operative action	Occurrence /shift
1—LI	—C mix tank	1	1	Mix next batch C	1/6
2—LI	—C feed tank	1	1	Pump mix to feed tank	1/3
3—LI	—A stg. tank	1	1	See general	
4—LI	—B stg. tank	1	1	See general	
5—PI	—A matl. line	1	1		
6—PI	—B matl. line	1	1	Check control valve	1/270
7—PI	—Pump discharge	1	1	Remove and clean scrn.	1/6
8—PI	—Pump discharge	1	1		
30—FRC	—Primary feed flow	4	28	General adjustment	1/3
				Check control valve	1/90
31—FrRC	—Scndry. feed ratio flow	4	28	Adj. fr. sp. g.—samp. 2	1/9
				Check control valve	1/90
9—LIC	—Feed tank	1	1	See 32	
32—PI	—Output air on 9	4	28	Check control valve	1/90
33—PRC	—Reactor outlet	4	28	Check control valve	1/3
10—PI	—Reactor feed line	4	4	Reactor washout	Remote
11—PI	—Reactor outlet	4	4		
12—LIC	—Reactor jacket water	1	1		Remote
13—PI	—Reactor steam vent		1/270	See 34	
34—PIC	—React jakt. water vap.	4	28	Check control valve	1/270
35—TR	—4 points	4	28	Inconjct. with others	
14—LI	—Flash still reboiler	4	28	General adjustment	16
15—PI	—Steam to flash still		1/270	Draw off fl. stil. bottoms	2
36—PIC	—Steam—fl. stil. reboiler	4	28	Check control valve	1/270
37—PIC	—Flash still	4	28	Check control valve	1/270
16—LIC	—Flash still accum.	1	1	See 38	
38—PI	—Output air on 16	4	28	Check control valve	1/270
17—LI	—Crude tank	1	1	See 40	
40—FIC	—Finish column feed	4	28	General adjustment	1/3
18—PI	—Finishing col.—bot.	4	4	See 41	
41—PIC	—Finishing col.—top	4	28	Check control valve	1/270
19—LIC	—Finish col. reboiler	4	4	See 42	
42—PI	—Output air on 19	4	28	Check control valve	1/270
20—PI	—Steam to finish col.		1/270	See 43	
44—TR	—4 points in column	4	28	General adjustment	1/3
43—TIC	—Fin. col.—stm. to reboil.	4	28	Check control valve	1/270
45—FRC	—Finish col. reflux	4	28	General adjustment	1/3
				Check control valve	1/270
21—LIC	—Finish col. accum.	1	1	See 46	
46—PI	—Output air on 21	4	28	Check control valve	1/270
22—LI	—Lights tank	1	1	Switch to alt. tank	1/9
23—LI	—Finished prod. tank	1	1	Switch to alt. tank	1/9
S-1	—Reactor feed		4	Adjust. var. flow pump	1/90
S-2	—Reactor discharge		4	Adjust var. flow pump	1/3
S-3	—Flash still bottoms		4		
S-4	—Finished product		4	Adjustments at instr.	
S-5	—Lights—finish. col.		4		

General and Related Duties (Occurrence/shift)

Notify fore. of trbl., oper. prob., etc.	1/3	Grease plugcocks	2
General area check	4	Adjust pump packing	1/3
Rec. & exchange shift info.	1	Change charts	1/3

Table 4.—Integral Activity Components and Times

	Elem. vol. std. min.	Factor	Total std. min.
Route I			
a—walk, bnch to panl—15'	.458	15/100	.069
b—ck. 31	.110		.110
c—ck. 30, 33, 34, 36, 37	.088	5	.440
d—ck. 32, 38	.044	2	.088
e—ck. 35-3 points	.044	3	.132
f—walk, panl to fl stl—12'	.458	12/100	.055
g—ck. 14 (site glass)	.099		.099
h—walk, fl. stil to panl—33'	.458	33/100	.151
i—ck. 40, 41, 43, 45	.088	4	.352
j—ck. 42, 46	.044	2	.088
k—ck. 44-4 points	.044	4	.176
l—walk, panl to bnch—5'	.458	5/100	.023
Subtotal			1.783
Pump C Mix to Feed Tank			
a—walk, bnch to stairway—15'	.458	15/100	.069
b—down 15 steps	.100	15/10	.150
c—walk to C mix tank—96'	.458	96/100	.440
d—opn plgck.—C mix tank	.091		.091
e—walk to C feed tank—75'	.458	75/100	.344
f—open plgck.—C feed tank	.091		.091
g—sw on to start pump	.033		.033
h—cttn to transfer	1.330		1.330
i—sw off to stop pump	.033		.033
j—close plgck.—C feed tank	.091		.091
k—walk to C mix tank—75'	.458	75/100	.344
l—close plgck.—C mix tank	.091		.091
m—walk to stairway—96'	.458	96/100	.440
n—up 15 steps	.122	15/10	.183
o—walk to bnch—15'	.458	15/100	.069
Subtotal			3.799
Check control valve			
a—walk, instr to vlv—16' avg.	.458	16/100	.073
b—ck. position of vlv	.047		.047
c—walk to bench—10'	.458	10/100	.046
d—get wrench fr. rack	.100		.100
e—walk to valve—10'	.458	10/100	.046
f—dism. union, air to diaphragm	.240		.240
g—air shock valve	.269		.269
h—assemble union	.171		.171
i—walk to bench—10'	.458	10/100	.046
j—replace wrench	.100		.100
k—return to route—6' avg.	.458	6/100	.028
Subtotal			1.166

example, if the same work element is being performed under adverse working conditions such as in extreme heat and fumes, the standard value will be higher than if it is performed under ideal surroundings. This is true because the adverse conditions cause the fatigue and the personal necessity requirements to be higher which in turn are reflected in the over-all value. Therefore the values shown in Table 1 are not intended for general usage although it is generally understood that they would be quite adequate for chemical processing operations in most companies.

Table 1 is a listing of work elements and the elemental standard time value for each. This listing includes only those elements which will be used in carrying out an application example. Values can of course be established for any work element required and in actual practice work element values are continually being added, revised, and modified.

Typical Chemical Process Flow Chart

Figure 1 is a typical chemical process flow sheet which serves as an example in applying the estimating method. In addition to material flows and equipment, it shows sampling points and the designation of all instruments located at the equipment and on the two instrument control panels.

Raw materials *A* and *B* are pumped from storage tanks and flow together in a line to the reactor feed tank. From the feed tank the mixture is pumped by a constant flow pump through a surge chamber to the reactor, with part being by-passed back to the feed tank in order to maintain flow to the reactor equal to the sum of the proportioned primary and secondary feed flows. Raw material *C* is mixed with some *A* in an agitated mix tank and pumped to feed tank. From the feed tank it is pumped by a variable flow pump into the reactor feed line. Reaction takes place under controlled conditions, heat of reaction being removed by boiling water in the shell. Reacted material is fed to the flash still where heavies are knocked out as bottoms and go to a sludge tank, and the overhead is accumulated as crude and pumped to crude storage. Crude is then pumped through a heat exchanger for preheat to the finishing column. Bottoms are finished product and flow through the preheat heat exchanger to the finished product storage. Overhead is unreacted material and is accumulated as such and pumped to storage with part being returned as reflux.

Considerations Preliminary to Method Application

Before the method of estimation is actually carried out, general consideration should be given to safety requirements, operating procedures, product economies and costs, and profit margins in order to determine whether or not an intrinsic minimum labor requirement is already fixed in the situation. Also study should be made to accomplish methods and equipment improvement, particularly if an intrinsic labor requirement thus can be eliminated. It should be stressed that if proper thought has been given to design and layout, these situations will be infrequent rather than general in occurrence.

Minimum safety requirements may dictate a specific number of personnel on the job or at least on some of the operations.

A prescribed number of personnel may be required to perform effectively certain operation and duties.

From the standpoint of product economy, a fixed number of personnel may be required to prevent equipment shutdown, or to carry out more quickly correction of trouble, startups, and shutdowns and thus gain or save production time. The same may be true in order to prevent equipment damage and thus save excessive maintenance and repair or replacement costs. In this case, the cost might be looked at as insurance cost for prevention of damage in lieu of insurance for replacement or repair of damaged equipment.

A fixed labor requirement may be economically sound in cases where varied equipment utilization and scheduling are necessary to meet frequently fluctuating production requirements particularly in batch-type operations.

These concerns are usually within the limits of one manpower requirement and the problem is one of balancing manpower cost against value of production gained or maintenance saved by being in operation rather than down, or by being able to carry out readily a proper scheduling sequence.

Therefore, in the above types of situations, it may be necessary to have a fixed labor requirement even though first indications are that a lesser number would be more than adequate. If such is true, the results indicated by the estimation should be tempered and adjusted accordingly.

INDUSTRIAL ENGINEERING

. . . is the engineering approach applied to all factors, including the human factor, involved in the production and distribution of products or services. Nearly every phase of industrial engineering directly involves people—both the people who do the work and people who are affected by the work. It is the proper and economical handling of the human factor that makes technical applications work.

Method—Steps and Application

The method used in determining direct labor requirement consists of six steps:

1. **Determine the operating and related procedure activities.**
2. **Break down each activity into its elemental work components.**
3. **Apply the elemental standard time value to each component.**
4. **Take the sum of the times to obtain total predictable standard work time.**
5. **Determine and apply an appropriate "process" allowance percentage**
6. **Take the sum of predictable time and process time to arrive at the total direct labor standard time requirement.**

In *step 1*, an analysis of the process and flow sheet is made to determine the operations and duties to be performed, their sequence and frequency. This analysis is made with the cooperation of supervision and technical personnel. This is best done by working through the flow sheet from the standpoint of control points and deciding:

a. **The frequency of checking each control point.**
b. **The operative action to be taken if the control point indication is other than expected.**
c. **The anticipated frequency of occurrence for the operative action.**
d. **The additional related duties which have no direct connection with control points.**
e. **The frequency of occurrence for such related duties.**

The results of this analysis are shown in Table 2. As examples of the analysis thinking, the following points are considered:

1—LI—check as shown—level low indicates material is almost used therefore, plan for and mix next batch—level high is impossible since the operator mixes a specific size batch—related action would concern check of malfunction of gear pump or agitator but this is considered remote.

4—LI—check as shown—level low indicates other building has not filled tank, therefore notify foreman—level high indicates other building is overfilling tank—action is to notify foreman, check with other building, or in emergency close fill valve, but is considered remote.

14—LI, 15—PI, 35—TR, 36—PIC—in conjunction with each other for operating purposes—check as shown—flash still is continuous batch operation. As cycle progresses and low boilers are driven over, steam is increased to vaporize the maximum amount of low boilers from an increasing amount of high boilers in bottoms. As reboiler level increases (14—LI), increase steam (36—PIC)

accordingly. Also from vapor temperature (35—TR) and results of sample 3, determine amount of adjustment. Adjust as shown. Final draw-off determination is made from analysis of level, temperatures, and sample 3 tests—draw off as shown. Related action would concern draw-off pump not working but is considered remote. Combination of level, vapor and bottoms temperature, and steam pressure (15—PI) may indicate 36—PIC control valve not operating properly. High pressure and air output low indicates control valve stuck open—check valve as shown. Control valve stuck closed is considered remote.

For purposes of simplicity in this presentation, duties outside normal operating procedure, such as reactor washout or other shutdown functions, have been omitted. Also these functions embrace an entirely different problem, that of the elapsed time that can be tolerated for their accomplishment. Thus to shorten down time, perhaps extra manpower help can be made available temporarily in order to accomplish the required duties in less elapsed time and, thereby increase actual time in production.

The control point checks and some related duties are initiated by direct instructions to "do." Once the frequencies for control point checks are decided, the scheduled occurrence sequence is established by analyzing the physical layout of the plant and determining the most effective travel routes to follow in order to perform all checks at their required frequency. The maximum time that can be allowed for any one route is always limited by the time interval between the highest frequency checks unless such checks can be made more than once on such route. In our example, this time interval is 15 min. The routes have been established so that the minimum distance is covered while keeping the required time per route to less than 15 min. Thought is given also to the fact that for certain control points, more frequent operative action or adjustments are anticipated. Therefore the routes in which these checks occur are purposely not as extensive in order to allow time for the operative action to be accomplished if possible in the 15-min. span. A logical time of day occurrence is also denoted for each route. This is tentative and may be temporarily varied by the operator if operating difficulties are encountered. The routes are listed in Table 3.

The operative actions, nonscheduled verifying control point checks, and remaining related duties are initiated by the sensory impressions received in checking the control points and therefore have no fixed occurrence sequence. These duties usually start from the operating-bench area following a route check, but if adequate time is available, such as is usually true for instrument adjustments, they are carried out from any point on the travel route.

In *step 2*, each control point check, operative action, and related duty is broken down into its elemental work components, with full consideration being made for the scheduled occurrence sequence, or position of occurrence of each component action as a part of an integral activity.

Step 3 involves applying the correct elemental standard-time value to each elemental work component and obtaining a time subtotal for each integral activity. Thus, with a comparatively small number of elemental times, the total time for many entire activities and operations may be built up. Attention time for certain operations such as transfers, loadings, drawoffs, etc., is a function of pump, line, and equipment capacities and is usually allowed as required for the short cycles. However, for such operations with longer elapsed time cycles, the attention time allowed is only that which is considered necessary for adequate control and checking. Examples of the process carried out in steps 2 and 3 are shown in Table 4.

In *step 4*, a list is made of the integral activities, their time subtotals, their occurrence per shift, and the total time per shift for each activity. The sum of the integral activity times thus obtained, as shown in Table 5, is the total predictable standard work time.

Step 5 consists of determining and applying a process allowance. Process is an amount of time added to the predictable total to allow for unavoidable and miscellaneous delays and holdups, variances in work procedure caused by upsets and irregularities, and work operations which occur so erratically and/or intermittently as to be unpredictable as far as inclusion in the regular standard times. It is usually expressed as a percentage of the predictable total. It has been found through many studies and observations that the extent to which these things occur depends upon the characteristics of the particular process and work duties involved and upon the coordination required between job functions and jobs. There are three or four pro-

DEFINITION AND ACTIVITIES OF INDUSTRIAL ENGINEERING

Since an industrial engineering approach is proposed, it is pertinent to define industrial engineering. The definition as developed by the American Institute of Industrial Engineers is:

> **". . . concerned with the design, improvement, and installation of integrated systems of men, materials, and equipment. It draws upon specialized knowledge and skills in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems."**

Its activities and techniques include: time and motion study . . . methods improvement . . . work simplification . . . wage incentives . . . job evaluation . . . production control . . . operations research . . . engineering economy . . . materials handling . . . cost and budgetary control.

Table 3.—Control Point Check Route Schedules

Route No.	Occurrence /shift	Occurrence time	Control points covered
I	20	8:15 & each quarter hour not on other routes	Ck. react and still panels and 14
II	4	8-10-12-2	I + rec I + ck. & rec 10, 11, 18, 19
III a.	1	8:30	I + ck. 5-8, tnk levels, 9 and 12
b.	1	12:30	Same as III a. + recording
IV	4	9-11-1-3	I + ck. 10, 11, 18, 19 + take samp. 1-5 + gen. area ck.
V a.	1	10:30	I + ck. 16, 21
b.	1	2:30	Same as V a. + recording

cess allowances, varying from 4 to 20 per cent, generally used and 8 per cent has been chosen as being adequate for the particular chemical process set up. Table 5 shows the process allowance time.

In *step 6* (final) the sum of the predictable and process allowance times is the total standard minutes of direct operating labor required to carry out the work. In our example this is 240 std. min. or approximately one half of one man's available time per shift. Standard time includes fatigue allowance or time for personal necessities and to recuperate from the mental or physical weariness brought about in doing the work. Therefore considerations are complete at this point.

The total shows not only that one man is adequate for the job but also that he would have time available to accomplish duties other than those listed. Such duties might include: janitorial cleanup; unload tank car of material A to storage; obtain and store bags of material C; package material; further minor maintenance.

In the example, attention has been confined primarily to direct operating activities. However, the above types of duties could also be included and an over-all labor requirement for plant operation determined.

Should more than one manpower be indicated by the estimation, a further analysis of the duties and their occurrence schedule is necessary in order to allocate properly the work to the personnel for efficient and effective operation.

Additional examination of the time results reveals an interesting distribution of the operator activities as shown in minutes per hour:

checking and attention to instruments	6.90
operating adjustments	.72
recording of readings	1.87
sampling and testing	10.80
work duties	2.08
travel movement	5.45

Table 5.—Standard Time Value Summary

Activity	Std. min.	Occur. fact. /shift	Std. min. /shift
Check Route I	1.783	20	35.660
Check Route II	4.925	4	19.700
Check Route III a	12.861	1	12.861
Check Route III b	14.248	1	14.248
Check Route IV	5.539	4	22.156
Check Route V a	4.494	1	4.494
Check Route V b	4.792	1	4.792
Titration (S-1, 2, 3)	2.050	3 × 4	24.600
Specific Gravity (S-2)	2.740	4	10.960
Consistency (S-3)	1.210	4	4.840
Distillation I (S-4)	3.980	4	15.920
Distillation II (S-5)	5.060	4	20.240
Mix batch C	10.602	1/6	1.767
Pump mix to feed tank	3.799	1/3	1.267
Chk. contr. valve	1.166	10/270	.043
Chk. contr. valve	1.166	3/90	.039
Chk. contr. valve	1.166	1/3	.389
Remove & clean screen	11.703	1/6	1.951
Adj. FRC—30	.330	1/3	.110
Adj. FrRC—31	.330	1/9	.037
Adj. PIC—36	.330	16	5.280
Draw flash still bot.	3.539	2	7.078
Adj. FIC—40	.330	1/3	.110
Adj. TIC—43	.330	1/3	.110
Adj. FRC—45	.330	1/3	.110
Switch tanks—22	.837	1/9	.093
Switch tanks—23	.837	1/9	.093
Adj. var. flow pump	4.869	1/90	.054
Adj. var. flow pump	4.869	1/3	1.623
Notify foreman	4.020	1/3	1.340
Grease plugcock	1.376	2	2.752
Adj. pump packing	2.407	1/3	.802
Change charts	13.153	1/3	4.384
Exch. shift info.	2.600	1	2.600
Total predictable std. time			222.503
Process allowance—8%			17.800
Total direct labor std. time requirement			240.303

Summary

This method may at first appear to be rather detailed and time consuming. However, once the basic elemental standard values have been established and training acquired in the procedure steps, it can be accomplished in a reasonably short time.

In this approach, a number of reactions may be encountered which the analyst should be prepared to handle. Usually the first response is that it is impossible to list and determine occurrence frequencies for all duties, particularly for a complex process. This is nicely eliminated by pointing out that ultimately personnel must be trained to do the work and this involves directing not only what is to be done, but how, when, where, who, and why. If this cannot be done, no one can ever be trained to do the work so the operation fails. If it can be done, the needed estimating information is available so the analysis proceeds.

Also there is sometimes a tendency to overestimate occurrence frequencies. This may be due to the normal desire of supervision to be sure of adequate personnel or the result of thinking in terms of extra activity, which often takes place during initial runs of new equipment rather than the activity required when in normal operation.

This approach is applicable not only to chemical process operation but to most types of work such as material handling, maintenance, and laboratory.

Some additional benefits to be gained are:

It provides supervision with a more intimate knowledge of operators' activities and the time required for their accomplishment.

It promotes an appreciation of the problems encountered by the worker and thereby provides a basis for determining man and job qualification requirements.

The information accumulated provides a good start for writing the operators' procedure manual.

Through the detailed breakdown it affords greater possibility for recognizing means of improving or simplifying work procedures.

By providing specific elemental times, it furnishes information for future reference as to the effect on labor requirement of equipment addition, alteration, or relocation.

It may aid in determining what is an optimum production rate for a given situation or for various sizes of labor force.

As a final thought, it is well to remember the axiom of the industrial engineer—"With sufficient study, any method can be improved."

Presented at A.I.Ch.E. meeting, Baltimore, Maryland.

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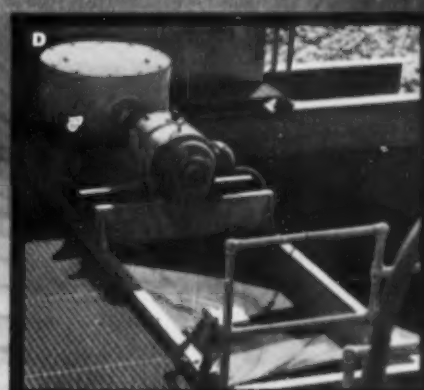

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SUN OIL DEDICATES NEW RESEARCH LABS

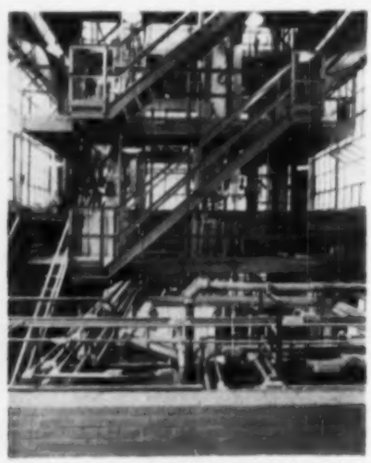
Intensive research "on the frontiers of petroleum technology" will be watchword at $2,500,000 Marcus Hook, Pa., research center.

Star performer at Sun's new research center at their Marcus Hook, Pa., refinery will be the new Houdriflow catalytic cracking pilot plant. The five-story pilot plant building accommodates two cracking towers, one 37 feet tall, the other rising to 68 feet. Here small-scale operations will be run to predict performance of full-scale units such as the giant catalytic cracking plant at Sun's Marcus Hook refinery (see photo).

The new laboratory building completes the consolidation under one roof of almost all of Sun Oil's research and development activities—basic research, product research, product development. In addition to the strictly research and analytical sections of the lab, auxiliary facilities are elaborate. A glass-blowing shop, a photographic laboratory, a completely stocked technical library of 15,000 volumes, and an electronic computer center are at the disposal of the staff of some 450 research technicians.

Speaking at the dedication ceremonies for the new lab, Chalmer G. Kirkbride, Sun's executive director of Research, Patent, and Engineering Departments, emphasized that, while modern equipment is an indispensable aid to research progress, the paramount role is still that of the creative individual.

Full-scale Houdriflow catalytic cracking plant at Sun Oil, Marcus Hook, Pa. Height, 360 feet; cost, $12,400,000.



Interior view of Houdriflow catalytic cracking pilot plant.

New Sun Oil research and development laboratory, Marcus Hook, Pa. Statue in foreground is memorial to 141 Sun seamen lost in World War II.

FIRST CANADIAN SULFONATE PLANT ON STREAM

The first plant for the production of petroleum sulfonates to be built in Canada has just gone on stream for Surpass Petrochemicals, Ltd. at Scarborough, Ont.

Costing $750,000, the new Surpass plant will produce seven million pounds a year of oil-soluble sodium sulfonates. It will also be equipped to produce sulfonates containing lithium, calcium, barium, ammonium, or amine.

In the new plant, designed and engineered by The Girdler Co., the primary sulfonation reaction takes place in a Votator multiport injection reactor—a specialized heat exchange unit produced by Girdler. Primary sulfonation, sludge separation, neutralization, and stripping are continuous operations, while the remaining steps are batch operations.

Process Details

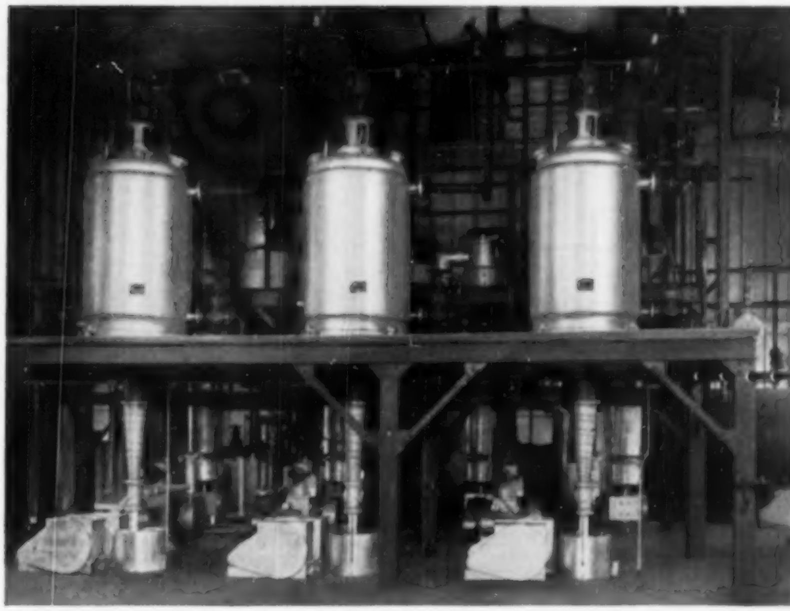
A set of proportioning pumps delivers oleum and a special cut of petroleum crude to the first Votator reactor. The reactor is water-jacketed to keep the temperature of the primary sulfonation reaction constant and to remove heat given off by the reaction.

Water and naphtha are added to the "sour oil" as it passes from the Votator unit into the sludge separation tank. The sludge is drawn off to waste and the "sour oil" is drawn off at the correct level to be pumped to the second Votator reactor where the neutralization is effected with caustic soda. From here the brine is separated and discarded, the oil goes to a steam naphtha stripper, and the neutral oil passes out at the bottom of the stripper into surge tanks.

From here the process becomes a batch operation. A secondary butyl alcohol and salt solution is added to the neutral oil, is thoroughly mixed, and the solution allowed to settle. Three distinct liquid phases result: the bottom, or brine, layer contains inorganic salts and low molecular weight organic impurities; the second layer contains the main product, concentrated sodium sulfonate; the top layer contains unreacted oil, SBA and water, and is separated for recovery of the oil.

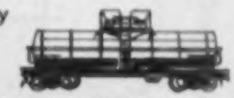
All vessels are of mild steel except the Votators, which are stainless. Most vessels operate at atmospheric pressure.

Surpass is a subsidiary of Montgary Explorations, Ltd.



Paraffin at a Fraction of a cent Per Pound!

Three Asco Molecular Stills at Trans Penn Oil Co. Can Produce More than One Tank Car Per Day



ASCO ROTA-FILM

The Only Molecular Still Sold on a Royalty-Free Basis

are you the 1 in 20 who knows how*

MOLECULAR DISTILLATION

can increase profits?

If you are that one, you know that Molecular Distillation can process organic compounds with molecular weights from 200 to 1250 and silicones and halocarbons to 4000.

This means that a broad range of processes can be carried out with *better results* and at *far less initial cost and far less operating cost* than by methods commonly used. Here are a few such processes:

- Vitamin Recovery from Natural Triglycerides
- Purification of Monoglycerides
- Isolation of Natural Oil Components
- Distillation, Decolorizing, Recovery
- Purification of Pharmaceuticals
- Removal of odors, colors and non-saponifiables from crude tall oil, fatty acids and materials of higher molecular weights in general.

Results and savings are often startling. For example, a leading pharmaceutical manufacturer *produces a tranquillizer from compazine base* (a previous impossibility) using an Asco Molecular Still—weekly savings more than equal still cost, and the product is purer! . . . A French chemical producer *distills electrical grade dioctyl phthalate* of high quality on a commercial scale. . . . A U. S. company de-glycerinates glyceride mixtures with remarkable economy, just one of the separations and distillations of glycerides possible with Asco Molecular Stills.

Many more similar cases can be cited in which Asco Molecular Distillation has increased profits, improved results.

*Based on Recent Survey of Chemical Engineers

Write: Dept. CEP-11

a s c o

ARTHUR F. SMITH COMPANY

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☑ Check These Asco Features:

- ☐ Capacity Per Unit Practically Unlimited
- ☐ Present Personnel Can Operate
- ☐ Accelerated, Turbulent Film
- ☐ Shorter Exposure Time
- ☐ Minimum Pressure Drop
- ☐ Largest Possible Open Path

Test at Low Cost!

A laboratory size Asco Rota-Film Molecular Still is now available. This permits inexpensive tests accurately transferable to Asco industrial models. Price is $391.

New Brochure

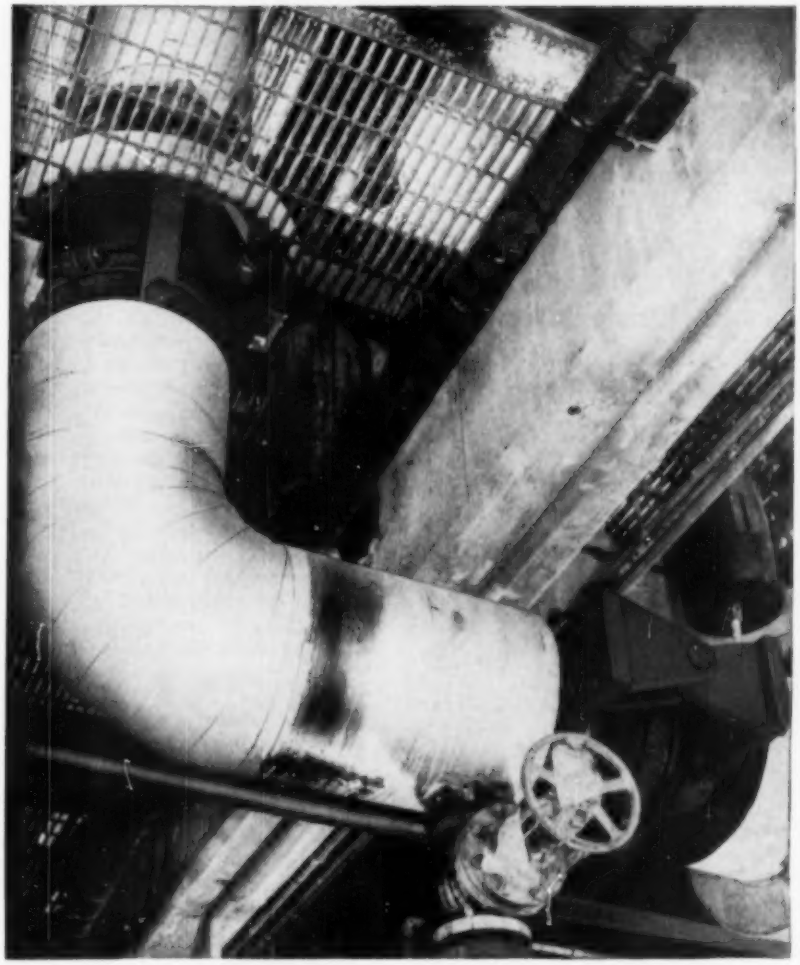
Fully Describes Models and Applications

Molecular Distillation for industrial application is growing rapidly. If you are not fully informed on its possibilities, send for free brochure, " . . . Molecular Distillation with the Rota-Film Still."

A unique project to save valuable water by building a "chemical shield" against the sun to reduce evaporation from lakes and reservoirs is in full swing at Rattlesnake Reservoir near Loveland, Colo. Adapted from reportedly successful work in Australia, the project is under the direction of the U. S. Bureau of Reclamation. Western reservoirs lose between three and eight feet of water each year through evaporation, and laboratory studies here have shown that up to 65 per cent of these evaporation losses could be eliminated with a "monomolecular" surface coating. In the picture, Bureau of Reclamation engineers are spreading the protective chemical coating (hexadecanol) over the surface of the reservoir by means of a doughnut shaped dispenser that floats on the surface. Prevailing winds then scatter the thin coating over the entire body of water. Hexadecanol is invisible and has no known effect on human or aquatic life. Much is looked for from the results of this summer's full-scale test. W. A. Dexheimer, Commissioner of Reclamation, says that, "If the treatment with hexadecanol can be made even 20 per cent effective, at low cost, the water savings would be tremendous." But research is still in the early stage, much work remains to be done before the Bureau can hope to predict even partial success.

Larger, maximum-load tank cars for high pressure materials are slated for large scale production for the first time. J. P. Krumech of Shippers' Car Line division of ACT Industries emphasized that maximum-load, high-pressure cars "represent the coming decade's major potential for tank-car builders." Maximum-load, or "jumbo," tank cars, are cars built to carry the heaviest permissible legal lading as determined by the rated strength of the railroad trucks on which the cars are mounted. Long in use for low-pressure commodities, high-pressure tanks are the next step, will find heavy use in the chemical industry. □

Major expansion plans for the manufacture of analog computers are underway at Mid-Century Instrumatic Corp. with the completion of a reorganization which added substantial new capital to the company. An ambitious program is aimed at broadening the market for analog computers, particularly in the chemical process industries. □



THIS IS WHAT

ADSCO

MEANS BY

SPECIAL

JOINTS

The photo shows a small but very important section of an insulated, spring-suspended 8″ pipe line in the new Moundsville, W. Va., plant of the National Aniline Division of Allied Chemical & Dye Corp. At the point shown, the line is subjected to complex stresses which are completely resolved and placed in balance by the ADSCO Gimbal Expansion Joint, upper left, and the ADSCO Hinge Expansion Joint, lower right.

In the Gimbal Joint, two sets of bars are pinned to the octagonal ring at 90° to each other. The other ends of the bars, still at 90° to each other, are pinned to the pipe leading into the joint. Running through the center of the ring, with a slight clearance, is a nipple connecting two expansion elements. This gimbal arrangement permits the joint to absorb 6° of angular movement from two different directions: the left and right motion of the horizontal part of the ell and similar motion from other unseen upper horizontal piping at 90° to the plane of the lower piping.

A partner to the Gimbal Joint and an indispensable part of this piping system is the Hinge Joint shown lower right. This absorbs the angular rotation of the ell caused by the expansion and contraction of the vertical piping.

There are so many motions involved in this section that, under certain conditions, the octagonal ring of the Gimbal Joint could describe a circle. Yet ADSCO and National Aniline engineers were able to identify all the motions and absorb them economically and efficiently by the Gimbal and Hinge Joints.

ADSCO designs and manufactures many types of both standard and special joints for many purposes. Consult ADSCO on any piping problem.

ADSCO DIVISION

YUBA CONSOLIDATED INDUSTRIES, INC.

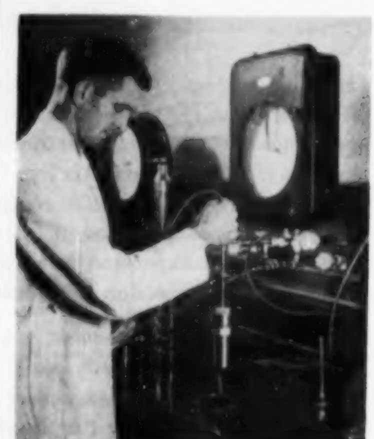
20 MILBURN ST. BUFFALO 12, N. Y.

INDUSTRIAL NEWS

Union Oil Company of California will realign its entire marketing operations for closer customer contact. The present four domestic territories will be made into 11 divisions. □

Latest entry into the linear polyethylene field is Du Pont. The company is designing a plant to produce the material on the Mississippi River upstream from New Orleans. Engineering plans and cost estimates are now being made and final decision on building will await the outcome of these studies. During the past two years, Du Pont has been producing experimental quantities of the polyethylene in a pilot plant at its Sabine River Works, Orange, Tex. Exactly what process will be used in Du Pont's plant is not determined. Two years ago the company acquired a license to use a catalyst developed by Ziegler, but Du Pont has not yet said whether it will use this catalyst in its projected plant. □

A $3 million naval stores plant has been put into operation by Newport Industries Co. Division of Heyden Newport Chemical Corp. at Telogia, Fla. Newport's fifth unit, the new plant will produce FF grade resin, turpentine, pine oil, and various terpenes by continuous fractionation of stump wood. □



A new, accelerated test to determine the oxidation stability of fats and oils has been developed by Eastman Chemical Products, Inc., a subsidiary of Eastman Kodak. The test is based on a modification of the Standard ASTM Oxygen Bomb Method by which gasoline stabilities are compared. Basically, the method, which is far more precise than standard methods, involves placing the fat or oil under 50 or 100 pounds per square inch of oxygen, raising the temperature to 212° F., and recording the time required for a significant pressure drop to occur. Details of the new method are available from Eastman Chemical Products, Kingsport, Tenn.

MAJOR EXPANSIONS, NEW USES BOOM NYLON 6

Allied will make a large scale expansion of its caprolactam plant, Foster Grant is building a Nylon 6 plant, and a German plastics expert predicts wide-spread use of nylon plastics by 1962.

Allied Chemical & Dye (National Aniline Division) is already underway in constructing additional facilities at its caprolactam plant at Hopewell, Va., that will double the capacity of the plant. This is the second expansion at Hopewell and will bring caprolactam production up to 60 million pounds a year. Main use of caprolactam is as the monomer for Nylon 6.

Sometime near the end of this year, or the beginning of next year, Foster Grant Co. will open its new Nylon 6 plant at Manchester, N. H. The process will be imported from Germany, along with much of the equipment, is entirely new to this country, and is considered by the company to be more economical than conventional processes. Foster Grant will be the fourth company to enter Nylon 6 production in the U. S.

Big in Europe, Growing Here

An increase in the use of nylon in automobiles alone in this country will bring the total in autos to 50 million pounds a year by 1962, predicted Dr. Carl Mienes, German plastics expert and European consultant for Foster Grant. Already widely used in Europe, nylon plastic is growing rapidly in importance here. In addition to its use in many parts of automobiles, Nylon 6 is expected to find application in food packaging, gears and other machine parts, nylon film, and housings for appliances.

Allied uses much of its caprolactam to produce its own Plaskon brand of Nylon 6. Sold by the Barrett Division, Plaskon is finding use in coil forms, cams, valves, gears, bearings and pressure tubing.

A second major market for Allied's caprolactam is in the production of synthetic fibers, such as Allied's own Caprolan.

Allied Chemical's National Aniline Division caprolactam plant at Hopewell, Va., which will soon double its capacity as Nylon 6 gains new application in this country.

NEW PROCESS COMBINES CARBOHYDRATES AND HYDROCARBONS TO MAKE NEW PRODUCTS

A practical, commercial and economical method of combining carbohydrates and hydrocarbons is ready for commercial application by Universal Oil Products and Corn Products Refining.

A unique method of combining sugar with petroleum compounds to produce materials of industrial importance as detergents, petroleum additives, pharmaceuticals, plasticizers, resins and germicides is now being readied for commercial development at Universal Oil Products Co. and Corn Products Refining Co. Developed by C. B. Linn of UOP, the new process offers a convenient and economical way to make a whole range of promising compounds from combining carbohydrates and hydrocarbons. Some of the products are completely new, and others, according to UOP, were formerly inaccessible from an economic point of view. In the lab Linn has taken sucrose, starch, cellulose, and glucose and "hooked" them chemically to toluene, ethylbenzene, phenol, and other petroleum derivatives through the use of hydrogen fluoride.

Process

The new process begins by taking the carbohydrate and the hydrocarbon and sealing them in a stainless steel vessel which is cooled with dry ice because there is a large amount of heat generated by the reaction. Hydrogen fluoride is pumped in and the mixture stirred until the action is complete. The excess HF is separated out and the product purified. The relatively delicate carbohydrate structures stand up surprisingly well through the entire process of uniting with the hydrocarbon.

Although several pure reaction products may be recovered from a given pair of reactants, it has been found possible to obtain a desired product in good yield by selecting the proper operating conditions. Compounds with an entire range of solubilities in water and in oil-type materials can be tailor-made by selection of carbohydrates and hydrocarbons of various molecular sizes.

The method is considered to be both economical and commercially feasible. Both UOP and Corn Products Refining Co. are making plans for the commercialization of the process and its products. Laboratory samples of two of the products are available upon request: 1-deoxy-1, 1-di-(ortho-xylyl)-D-glucitol, made from orthoxylene and starch; and 1-deoxy-1,-di-(para-hydroxyphenyl)-D-glucitol, from phenol and starch.

Condensed from a paper delivered at the recent ACS meeting in New York.

Designs are on the boards for a semiworks plant to produce Lexan, General Electric's polycarbonate resin. Designers are Crawford & Russell, Stamford, Conn. Sample lots of the new plastic are expected to be available late in 1957. □

Canada's first titanium pigment plant has just gone on stream at Varennes, Quebec. Built by Canadian Titanium Pigments Limited, a subsidiary of National Lead Co., the new plant will make Canada virtually self-sufficient in titanium pigments. □

Du Pont has taken a license to one of Lea-Ronal's bright copper plating patents. The patent covers "Bath for Plating Bright Copper." □

INDUSTRIAL NEWS

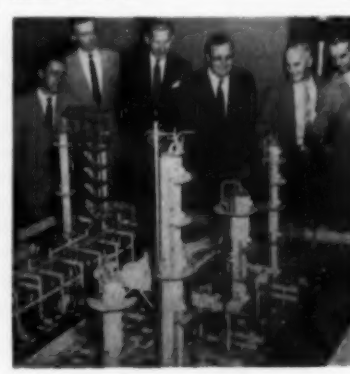
Fluor Corp., Ltd., has acquired a Datatron stored-memory, medium-speed, electronic digital computer. The quarter-million-dollar installation will be used to do engineering calculations in the process and mechanical design of petroleum, chemical, petrochemical, and power plants. □

A newly-completed addition to the Toledo plant of Barrett Division, Allied Chemical & Dye, has made it the largest polyester producing operation in the country. A year in construction, the new facilities more than double the production capacity for Plaskon Polyester. □

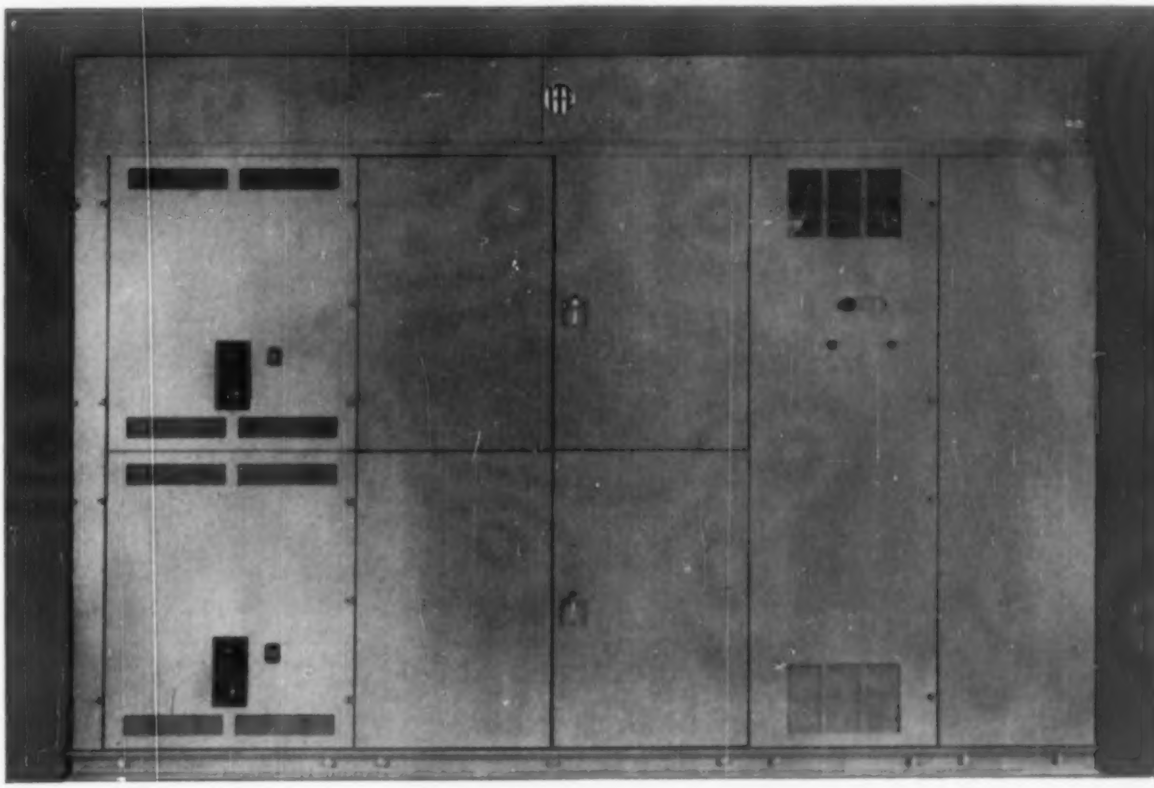
Savings of about $1 million in the design and construction of a complex petroleum refining plant are expected by Esso Research and Engineering through the use of techniques involving electronic computers. The use of a computer also cut the basic engineering time and manpower for the project by at least one-half. The work was completed three months earlier than if it had been done by hand. Aim of Esso program is to get better designs, to free engineers from routine and repetitious chores, to get jobs done more quickly, and to make designs more consistent. □

An expansion program has doubled the capacity of the Brunswick, Ga., mercury cell chlorine-caustic soda plant of Solvay Process Division, Allied Chemical & Dye. □

Sun Chemical Corp. has signed a contract to buy Ansbacher-Siegle Corp., a leading pigment manufacturer. Purchase price is 225,000 shares of Sun Chemical common, contract is subject to approval by Sun's stock owners. □



A portion of the design model of Standard Oil of Ohio's new $34 million Toledo refinery now being constructed is studied by engineers from Sohio and the M.W. Kellogg Co. The scale model, built in Kellogg's New York model shop, was used as a design tool and in making the final design review.



New I-T-E Semi-Conductor Rectifier has a capacity of 10,000 amp at 300 v d-c.

NEW I-T-E SEMI-CONDUCTOR RECTIFIER —See it at the Chemical Exposition, N.Y. Coliseum, Dec. 2-6, Booth 1029

This new rectifier is being exhibited for the first time at this show. Come look it over. Get firsthand engineering information. In addition, you can see on display all this other I-T-E equipment:

Hall generator. Precision d-c measuring device.

Mechanical rectifier contact mechanism. 97% efficient.

High current d-c bus and cell switch.

Power switching center. Enclosed, fused interrupter switch. Ratings available up to 14.4 kv, 1200 amp.

6-pole anode circuit breaker. Has unique new single pole drawout feature.

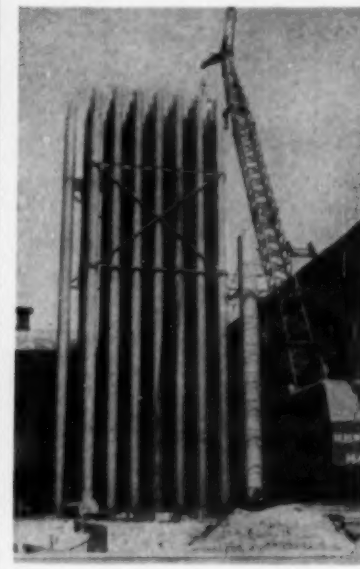
I-T-E

TRANSFORMER & RECTIFIER DIVISION

I-T-E CIRCUIT BREAKER COMPANY

19TH AND HAMILTON STREETS, PHILADELPHIA 30, PENNSYLVANIA

INDUSTRIAL NEWS



These vertical pressurized oxygen storage tubes have been installed by Air Products, Inc., for Granite City Steel Co. at Granite City, Ill. First of their type in the steel industry, the tubes tower 80 feet above the ground, will hold 125,000 standard cubic feet of 99.5 per cent pure oxygen. The high-purity oxygen is stored under 450 lb./sq.in. pressure. The new installation requires only a fraction of the space needed for a flat bank.

Fielden Instrument Division of Robertshaw-Fulton Controls Co. has been renamed the Instrument Division, will continue in the same Philadelphia headquarters. □

Latest entry into the fast-growing ultrasonics industry is a newly-formed subsidiary of The Narda Microwave Corp., Mineola, L. I., N. Y. Named the Narda Ultrasonics Corp., the new subsidiary will promote and mass produce ultrasonic cleaning machines and metalworking equipment. □

Crude refining capacity will be increased to 15,000 bbl. a day at Bay Refining Corp., a wholly-owned subsidiary of Dow Chemical. Expansion will involve installation of a new topping unit for processing crude oil, completion is expected about October 1, 1958. □

A new inhibited decyl alcohol that yields improved esters has been introduced by the Enjay Co. The addition of the inhibitor protects alcohol during the esterification process and prevents any appreciable color formation. The additive is removed from the ester during the course of normal purification, no special treatments are required. Important economies are said to be effected. □


This pneumatic flow control gives
LIVE-ACTION RESPONSE . . . 1000 feet from panel!
Complete elimination of controller-to-valve response delay! True close-coupled control even when the operating panel is *hundreds* of feet away. These are big features you'll find in the Foxboro Model 59 flow control system.
The M/59 is the only controller specifically designed for direct mounting on the control valve motor. Need for brackets and controller-to-valve piping is eliminated. This unique force-balance controller has only two moving parts. There's no explosion hazard with this all-pneumatic system. And there are no bearings; no linkages—nothing to align or go wrong.
Learn how the fast response and simple adjustment of the low cost M/59 Controller, teamed up with the Foxboro d/p Cell Transmitter, will improve control of your process flows. Write today for Bulletin 470.
The Foxboro Company, 9311 Neponset Ave., Foxboro, Mass., U.S.A.
MODEL 59 VALVE-MOUNTED FLOW CONTROLLER
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FLUID FLOW SYSTEMS

VERSATILITY

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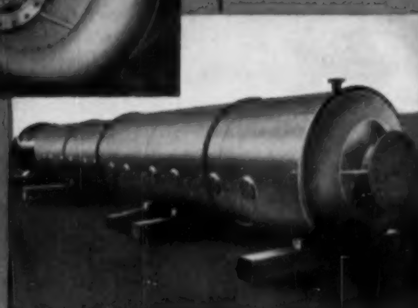
STEEL
Distilling Column

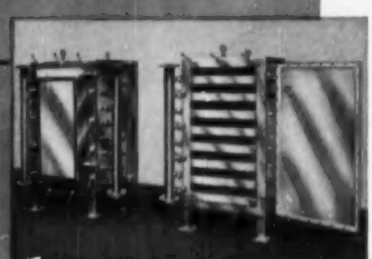


Leading Process Industries have come to depend on Acme for more efficient equipment for virtually any purpose. Acme versatility has paid dividends to many processors in time and effort saved, in greater economy of operation and more productive yields of high quality products.

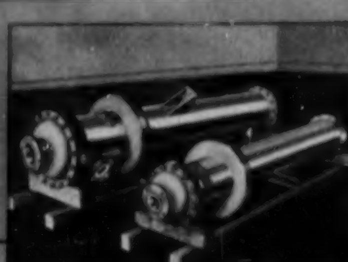
The illustrations shown here are but a few from thousands of diverse units in current, successful use all over the world.

When planning a replacement or expansion program, consult Acme first!

STAINLESS STEEL
Tray Dryers, ACME Design



COPPER
Scotch Whiskey Stills, 13' 7" and 12' 6" Diameters



ALUMINUM
Heat Exchangers

ACME
Processing Equipment
ACME COPPERSMITHING & MACHINE CO., ORELAND, PA.

DESIGN AND FABRICATION IN ALL FERROUS AND NON-FERROUS METALS.

CEP Data Service

Engineering Data . . .

EQUIPMENT

301 Spiral Heat Exchanger. Bulletin from American Heat Reclaiming Corp. describes characteristics and operating features of their spiral design heat exchangers.

302 Bulk Material Handling Systems. Comprehensive, 20-page illustrated booklet on use of the "Tote" system of materials handling. Tote System, Inc.

303 Shut-off Valves for Cryogenic Media. Hydromatics, Inc. announces availability of new series of light weight, pressure-operated, shut-off valves designed for extreme low temperature and high pressure applications. Technical data.

304 Density and Gravity Control Units. JSP series radiation type measuring equipment can control the density and gravity of any process material passing through a pipe, either vertically or horizontally. Details from Instruments, Inc.

305 Valve Catalog. Brochure from Anderson, Greenwood & Co. gives characteristics, specifications, and materials of construction on their line of precision valves—relief, metering, pilot-operated, hand types.

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307 Aluminum Jacketing. For insulated lines, towers, vessels, and tanks in the chemical process industries. Data from Aseeco, Inc.

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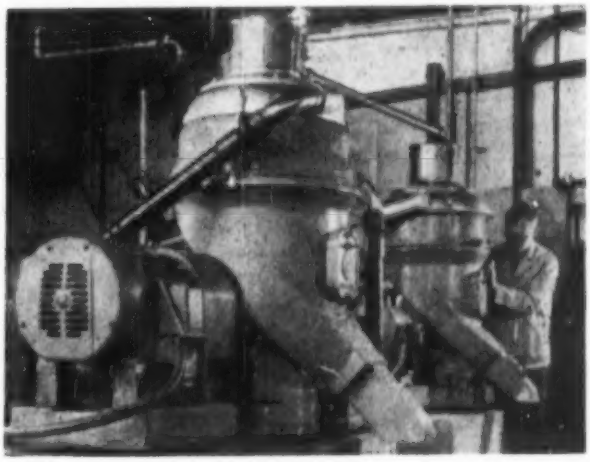
311 Pyrex Pipe for Corrosive Wastes. Bul-

(Continued on page 82)

PFAUDLER ACQUIRES NORTH AMERICAN RIGHTS TO DANISH-DESIGNED CENTRIFUGE



Rights to the Titan Superjector line, including the world's largest disc-type centrifuge (up to 6,000 gal./hr.) now belong to Pfaudler through their recent acquisition of Pitmar Corp., exclusive North American representative for the Titan Corp., Copenhagen, Denmark. The units being marketed here are project-engineered, assembled, installed, and guaranteed by Pfaudler.

The Titan Superjector has a series of 1/4-in. slots around the bowl circumference which periodically discharge solids while the unit is operating at full speed. Increased production is assured since the unit can be operated continuously for as long as one month. Cleaning is accomplished automatically in ten seconds or less.

Low power consumption is claimed since there is no braking effect from the periodic discharge of solids. In addition, infrequent disassembly of the bowl reduces the possibility of damage to parts in routine maintenance. Complete details are available from Pfaudler. Circle number 630 on Data Post Card.

"BUILDING BLOCK" PRINCIPLE IN GRAPHITE HEAT EXCHANGERS

The "Polybloc" graphite heat exchanger, developed and manufactured by the Carbone Corp., is built up of interchangeable identical blocks permitting a complete range of sizes. The elimination of cemented joints is said to prevent chemical or thermal decomposition, differential expansion, or mechanical weakness. The corrosive fluid contacts only the impermeable graphite.

(Continued on page 88)

CEP Data Service

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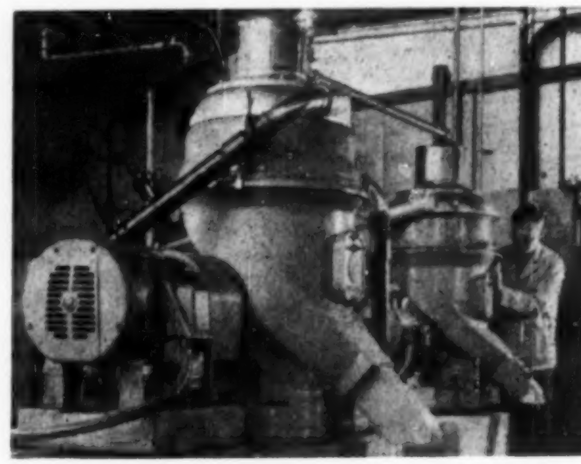

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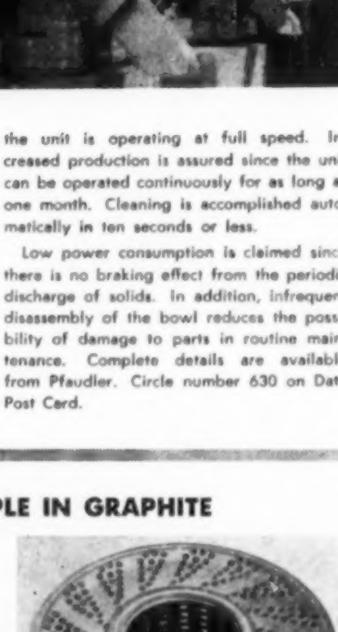

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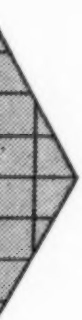

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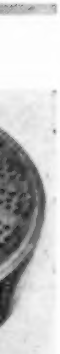
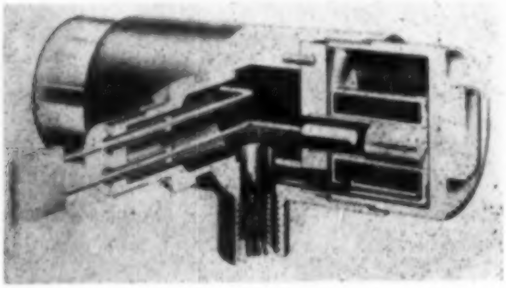
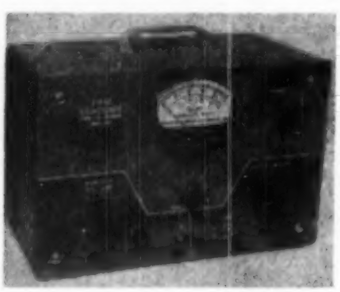


DEVELOPMENTS OF THE MONTH (Cont.)



632 New Type Level Control. The "Dynatrol," Model CL-O, product of Automation Products, Inc., is said to utilize a new design principle for extremely accurate and versatile high or low point detection or narrow range proportional control of liquid, solid, and slurry levels. The control has a positive acting electrical output control signal that varies with the amount of immersion of the 120 cycle/sec. vibrating paddle in the medium being detected. The output signal can be used to control the operation of any type of electrical equipment. The design allows sensitive transmission of vibrational energy from the driver end to the sensing paddle and back to the output signal end through a linkage path welded to rigid metal pressure seals at the node points where zero amplitude of vibration occurs. The unit is rated for 3,000 lb./sq.in., is supplied in corrosion-resistant materials. For further information circle number 632 on Data Post Card.



633 Ultrasonic Liquid Level Indicator. In the Echogage, Model 300, made by Bogue Electric Manufacturing Co., the ultrasonic pulse-ranging principle of liquid level measurement is employed to eliminate the need for floats, linkages, synchros, or any moving parts. Liquid level is read directly in feet on a large meter provided with two ranges to accommodate tanks up to 15 feet high. A built-in calibration feature assures correct level readings despite changes in velocity of sound propagation caused by varying temperatures, specific gravities, etc. One common indicator will gauge as many as 6 transducer-equipped tanks within a radius of 1,500 feet. Additional tanks can be accommodated by use of an auxiliary switch. The indicator is fully transistorized for maximum reliability, consumes only 5 watts of 120 volt, 60 cycle power. For further information circle number 633 on Data Post Card.

(Continued on page 82)

Numbers followed by letters are for checking your interest in the products, equipment, and services advertised in this issue, the number corresponding to the page on which the ad appears. Letters indicate position on the page: L, left; R, right; T, top; B, bottom. A indicates a full page; IFC, IBC, and OBC are cover advertisements. **Numbers in the 300-series** bring you new engineering data in the chemical engineering field.

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PRODUCTS ADVERTISED IN THIS ISSUE

IFC Polyurethane Foams. Union Carbide Chemicals Co. offers samples and specifications of polyurethane foams made from new **Niax Diol PPG 2025** (polypropylene glycol 2025—resin grade).

3R Rotary Sifter Bulletin. Describes Model "M" Bar-Nun rotary sifter, available with from 2 to 78 sq.ft. of surface for single or multiple separation of dry materials. B. F. Gump Co.

4A Entrainment Separators, Liquid-Liquid Extractors. Bulletins from Otto H. York Co. give details of Yorkmesh Demisters and York-Scheibel liquid-liquid extractors.

7A Water Purification Filters. Permutit Co. offers technical information on the selection of filters for water conditioning.

8L Mix-Mullers. Simpson Mix-Muller Division, National Engineering Co., will conduct mulling tests on your own materials under your supervision.

9A Steam Jet Apparatus Bulletin. Covers complete line of jet apparatus made by Schutte and Koerting Co. Includes many applications.

10A-11A Centrifugal Contactors. Podbielniak, Inc., offers technical literature on Podbielniak Contactors, said to be world's largest capacity centrifuges.

12L Fabricated Process Equipment. Heat exchangers, steel and alloy plate fabrication, containers and pressure vessels. Bulletins from Downingtown Iron Works, Inc.

13A Air and Gas Handling Equipment. Centrifugal, Spiraxial, and rotary positive blowers, exhausters, and compressors, rotary positive gas pumps and meters, rotary vacuum pumps. Roots-Connersville Blower.

14A Mixer Catalog. Technical data from Philadelphia Gear Works, Inc., on their line of vertical or horizontal motor drives.

15A High Pressure Centrifuges. Sharples Corp. exhibit at the Exposition of Chemical Industries, New York Coliseum, Dec. 2, will feature three new centrifuges designed for operation at high pressure and high thruput capacity.

16L Chlorine Cooling Towers. The Knight process for cooling and drying chlorine cell gas utilizes direct countercurrent contact in packed towers. Maurice A. Knight.

17A Filter Bulletin. All Adams filters provide safe cleaning without disassembly by a sudden, high velocity reverse flow of backwash liquid. Details from R. P. Adams Co.

18A Teflon Pump Catalog. Describes new line of Teflon pumps made by Vanton Pump and Equipment Corp. No stuffing-box or shaft seals.

22A Dryers. High speed or low, heavy capacity or light, continuous or batch

methods. Technical data from C. S. Sargent's Sons Corp.

23A Design, Engineering, Construction Services. New synthetic nitrogen plant built by Girdler Co. for Southern Nitrogen Co. will produce over 250 tons of ammonia a day.

24L T. Shriver & Co. exhibit at Exposition of Chemical Industries, New York Coliseum, Dec. 2, will feature new horizontal plate filter and new diaphragm pump.

25A Static Seals. Gask-O-Seals, product of Franklin C. Wolfe Co., Division of Parker Appliance Co., provide effective sealing in temperature range from minus 400 to plus 1,000° F. for specific applications.

26A-27A Centrifugal Pumps. 70,480 combinations from standard, stocked parts are possible in Worthington Corp.'s Standard End Suction Centrifugal Pump Line. In iron, steel, bronze, Worthite.

28L Vertical Chlorine Vaporizers. Standardized, heavy duty type vaporizers for chlorine in sizes from 180 to 16,500 lb./hr. Richard M. Armstrong Co.

29A Stainless Steel Reactor Vessels. Crucible Steel Co. of America offers booklet "Making the Most of Stainless Steel in the Chemical Process Industries."

30A-31A Engineering Services. Folder from Artisan Industries describes services they offer to the chemical, pharmaceutical, petroleum, food, process, and electronics industries.

veying or evacuation of erosive, corrosive, explosive, or high-temperature gas. Bulletin.

40L Telemetering Systems. Vapor Recovery Systems Co. offers booklet "A Comparison of Telemetering Systems," also bulletin on pulse code telemetering.

41A Tower Packing Bulletin. Full technical information on Pall Rings and other tower packings from U. S. Stoneware.

42A Clarifier Bulletin. Technical data on the Westfalia KG Clarifier, made by Centrico Inc.

43A Carbon and Graphite Structures. Combustion chambers, reactor vessel linings, bubble cap trays, packing support structures. Also "Karbate" heat transfer systems and "Intalox" saddle packing in carbon. National Carbon Co.

44L Stainless Steel Heat Exchangers. Detailed technical literature on multi-pass coolers, reboilers, condensers. Doyle & Roth Manufacturing Co.

45A Project Engineering. Every Badger project is headed by a "Key Man" who is always a Badger principle. Badger Manufacturing Co.

46A Filters. Horizontal plate filters, heavy duty water filters, disc plate trap filters. Sparkler Manufacturing Co.

47A-48A U.S. Industrial Chemicals Co. offers bulletins on zirconium and titanium, sodium peroxide bleaching of pulp, silicone by sodium process, polyethylene in cooling tower grids, other technical developments.

drying problems available from Louisville Drying Machinery Unit, General American Transportation Corp.

58A-59A Process Equipment. Pfaudler Co., division of Pfaudler Permutit Inc., offers bulletins on "R" series reactors, wiped-film evaporators, heat exchangers, Titan centrifuges, conical dryer-blenders, dispersion mills.

60A Heat Transfer Systems. Technical information from Monsanto Chemical Co., Organic Chemicals Division, on heating systems using Aroclor 1248, a non-pressurized, liquid-phase, heat-transfer fluid.

62A Pneumatic and Mechanical Conveying Systems. Fluor Products Co., Hartmann Division, offers application information on conveying, dust removal and classifying systems designed by Maschinenfabrik Hartmann A. G., Offenbach/Main, Germany.

512A Relief Valves. Bulletin from Crosby Valve & Gage Co. describes complete line of Crosby relief valves.

63A Turbo-Mixers. From 2 in. to 20 ft diameter, ¼ to 500 hp. Technical details from Turbo-Mixer Division, General American Transportation Corp.

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32A Filters. Industrial Filter & Pump Mfg. Co. offers technical information on new vertical, bottom outlet, Type "152" filter.

33A Process Equipment Fabrication. Dryers, coolers, calciners, kilns. Individual units or complete systems including all materials handling, processing, and storage facilities. Bulletin from C. O. Bartlett & Snow Co.

34A Materials Handling Equipment. Conveyors, feeders, grizzlies and screens, elevators. Bulletins from Stephens-Adamson Mfg. Co.

35A Plants for Resins and Plastics. With 25 years in the resins and plastics field, Blaw-Knox Co. is equipped to offer plants tailored to individual needs at minimum cost.

36L Transistorized Temperature Controller. Scale ranges for all standard calibrations covering temperatures from minus 320 to plus 3,000° F. Thermo Electric Co.

37A Water Supply Systems. Analysis, research, design, wells, pumps, maintenance, engineering. Layne & Bowler, Inc. Memphis.

38A Control Valves. Bulletin from Hammel-Dahl Co. describes operating features of the newly-modified Hammel-Dahl standard 3000 series control valve.

39A Fan and Ejector Stack. The Out-of-Circuit PD Fan and Ejector Stack, made by Prat-Daniel Corp., is designed for the con-

49A Activated Carbon. Barnebey-Cheney offers regeneration service for all types of activated carbons.

50A "Products and Processes" Booklet. Describes research in many fields at Union Carbide Corp.

51A Equipment Fabrication. Sun Shipbuilding & Dry Dock Co. specializes in fabrication and shipment of large processing units.

52L Magnetic Liquid Level Gage. Detailed engineering data on new magnetic gage for liquid levels from Jerguson Gage & Valve Co.

53A Equipment Fabrication. Graver Tank & Manufacturing Co. has completed 100 years of craftsmanship in steel and alloy equipment fabrication.

54A Process Equipment. Transfer oil heating systems, jacketed kettles, gas precoolers, converters, etc. Whitlock Manufacturing Co.

55A Filter Equipment. Design and fabrication of all types of filtering equipment. Eimco Corp.

56L High-Pressure Needle Valves. Bulletin from August Spindler & Sons, Inc., gives specifications of large and small high-pressure needle valves in 416 stainless or other alloys.

57A Drying Equipment. Research, engineering, design, and production services on

65A Molecular Distillation Brochure. Fully describes models and applications. Arthur F. Smith Co.

66L Swivel Joints. Eight basic styles, over 500 models. From high vacuum to 15,000 lb./sq.in., from sub-zero temperatures to 750° F. Continental-Emsco Co.

67A Special Joints. Adsco Division, Yuba Industries, Inc., designs and manufactures many types of standard and special piping joints. Consulting services available.

68L Peristaltic-Action Pumps. Bulletin from American Instrument Co. describes small and large models for pumping liquids through rubber or plastic tubing.

71A Molecular Sieve Adsorbents. Linde Co. offers data sheets on "Drying of Gases."

72L Differential Pressure Unit. Model 199 differential pressure unit, made by Barton Instrument Corp., available for pressures to 6,000 lb./sq.in. gauge.

73A Semi-Conductor Rectifier. Capacity of

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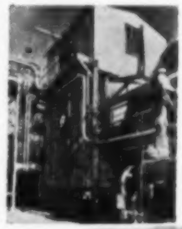

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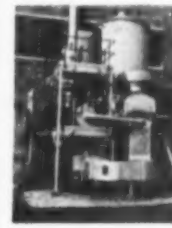

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Engineering Data . . .

(Continued from page 77)

letin from Corning Glass Works lists over 100 troublesome chemicals that can be handled. Drawings, charts, and many photos.

312 Bronze and Iron Body Valves. 136-page hard-cover book treats complete line of valves made by Fairbanks Co. Includes helpful technical data for initial design of piping layouts.

314 "Fluid Energy" Pulverizing Mills. The "Jet-O-Mizer," produced by the Fluid Energy Processing & Equipment Co., controls grinding action, classification, quality. Bulletin.

315 Steam-Jacketed Valve Bulletin. Revised bulletin discusses in detail the principle and operation of the non-lubricated split-plug valve made by Gato Valve Co.

316 Unit Heater Booklet. 26-page brochure from Westinghouse Electric, Sturtevant Division, describes construction and application of new line of commercial and industrial unit heaters.

317 Control Valves. Balanced, single-seated, tight-closing. Bulletin from Schade Valve Manufacturing Co.

318 Instrumentized Weighing Systems. Bulletin compares batch-in, batch-out, and continuous weighing processes, and explains assembly of completely automatic weighing systems. Weighing and Control Components, Inc.

319 Inert Gas Generators. Wide range of standard models using either gas or oil as fuel. Multiple-burner units available for very large capacity requirements. All units are package type with all controls included. Bulletin from Thermal Research & Engineering Corp.

320 Forged Steel Valves. Catalog from Orbit Valve Co. gives specifications and engineering data, prices, on forged steel ASA class valves. Available with full round or venturi openings.

321 Industrial Oil Heaters. Adapted for heating transfer oils or other liquids to temperatures up to 600°F. Complete technical information from Cleaver-Brooks Co.

322 Direct-Driven Fans. Bulletin from Aerovent Fan Co. gives details on new "LS" type direct-driven fans designed for low static pressure ranges. Ring, square panel, or duct types, in sizes from 24 to 48 in.

323 Diaphragm Spray Nozzle Data Sheet. New design equipped with manually-operated shut-off. In brass with internal Monel strainer. Wide choice of interchangeable orifice tips. Spraying Systems Co.

324 High-Capacity Chlorinator. Can meter and feed up to 8,000 lb. of chlorine/24 hr. Feed rate may be adjusted manually or controlled automatically on a flow proportional or selective rate basis. Brochure from Wallace & Tiernan, Inc.

325 Steam-Reactivated Dehydrators. For drying instrument air or process gas. Available in 11 sizes, from 10 to 1,000 std. cu.ft./min. (air at 70° F. and 100 lb./sq.in.). Details from Selas Corp. of America.

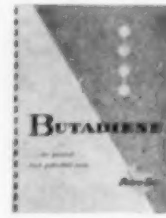
326 Temperature Monitor. A scanning and indicating device that automatically checks the temperatures of up to 40 thermocouples in the range of 100 to 400°F. every 10 sec. Technical data from Pickard and Burns, Inc.

327 Variable-Orifice Desuperheater. Bulletin from Copes-Vulcan Division, Blaw-Knox Co., gives schematic illustrations and explanatory text outlining working principle of their new advanced-design desuperheater.

328 Continuous Strainer Bulletin. Design, operation, applications, advantages of Merco Rotary and Merco Bantam strainers. Sectional line drawings and standard specifications. Dorr-Oliver, Inc.

329 Moisture Content and Density Instrument. The "d/M-Gauge" is a new portable field instrument for rapidly measuring moisture content or density of a wide range of organic and inorganic materials by measurement of the "scattering" of radioactivity. Details from Nuclear-Chicago Corp.

DEVELOPMENTS OF THE MONTH (*Cont.*)



634 Butadiene Technical Manual. Petro-Tex Chemical Corp. offers what is claimed to be the first technical manual ever printed on subject of butadiene. The 42-page book contains complete physical properties, polymerization data, chemical properties, detailed information on all principal butadiene reactions. It includes a series of six "family trees" showing the chemical structure of present and potential products resulting from various classes of reaction, cites some 286 literature references. Book should be of use to those interested in butane-based hydrocarbons, elastomers, fibers, plastics, coatings, etc. To obtain copy circle number 634 on Data Post Card.

(Continued on page 84)

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

(Continued from page 80)

10,000 amp. at 300 v., dc. Transformer & Rectifier Division, I-T-E Circuit Breaker Co.

74L Vertical Jacketed Pumps. For pumping liquids such as sulfur, phthalic anhydride, resins, waxes, etc., which tend to solidify or become viscous at low temperatures. Bulletins from Lawrence Pumps, Inc.

75A Fluid Flow Systems. Bulletin from Foxboro Co. describes features of the Foxboro Model 59 flow control system.

76A Equipment Design, Engineering, Fabrication. In steel, stainless steel, copper, aluminum. Acme Coppersmithing & Machine Co.

81A Spray Drying Book. Bowen Engineering, Inc. offers free book "The Bowen Laboratory Spray Dryer."

83A Heat Transfer Medium. Dowtherm, product of the Dow Chemical Co., provides temperatures to 750° F. at pressures below 150 lb./sq.in. Technical data available.

85A Equipment Fabrication. In stainless steel, aluminum, Monel, Inconel, all clad materials, nickel-plated steel. Catalog file and chemical engineering file from Koven Fabricators, Inc.

87A Crystallizers. Conkey crystallizers provide premium crystals, operating economy, low erection cost. Chicago Bridge & Iron Co.

89A Pump Data. Full technical data available from Aldrich Pump Co. on their complete line of process pumps.

93A Dust Collector Bulletin. Describes the Mikro-Pulsaire, made by Pulverizing Machinery Division, Metals Disintegrating Co. No internal moving parts, continuous automatic cleaning.

95A Heat Exchangers. Creative engineering and precision manufacturing on tap at Yuba Consolidated Industries, Inc.

97A Carbon Monoxide Plants. Consulting services on cost analyses and technical aspects in design and manufacture of complete plants or components. American Air Liquide.

99A Heat Exchangers. Engineered to special as well as standard specifications. M. W. Kellogg Co.

101A Process Compressors. Ingersoll-Rand offers information on several types of process compressors for pressures up to 35,000 lb./sq.in.

103A Teflon Control Valve. Body, stuffing box, integral seat, internal ports precision machined from solid block of Teflon. Complete details from George W. Dahl Co.

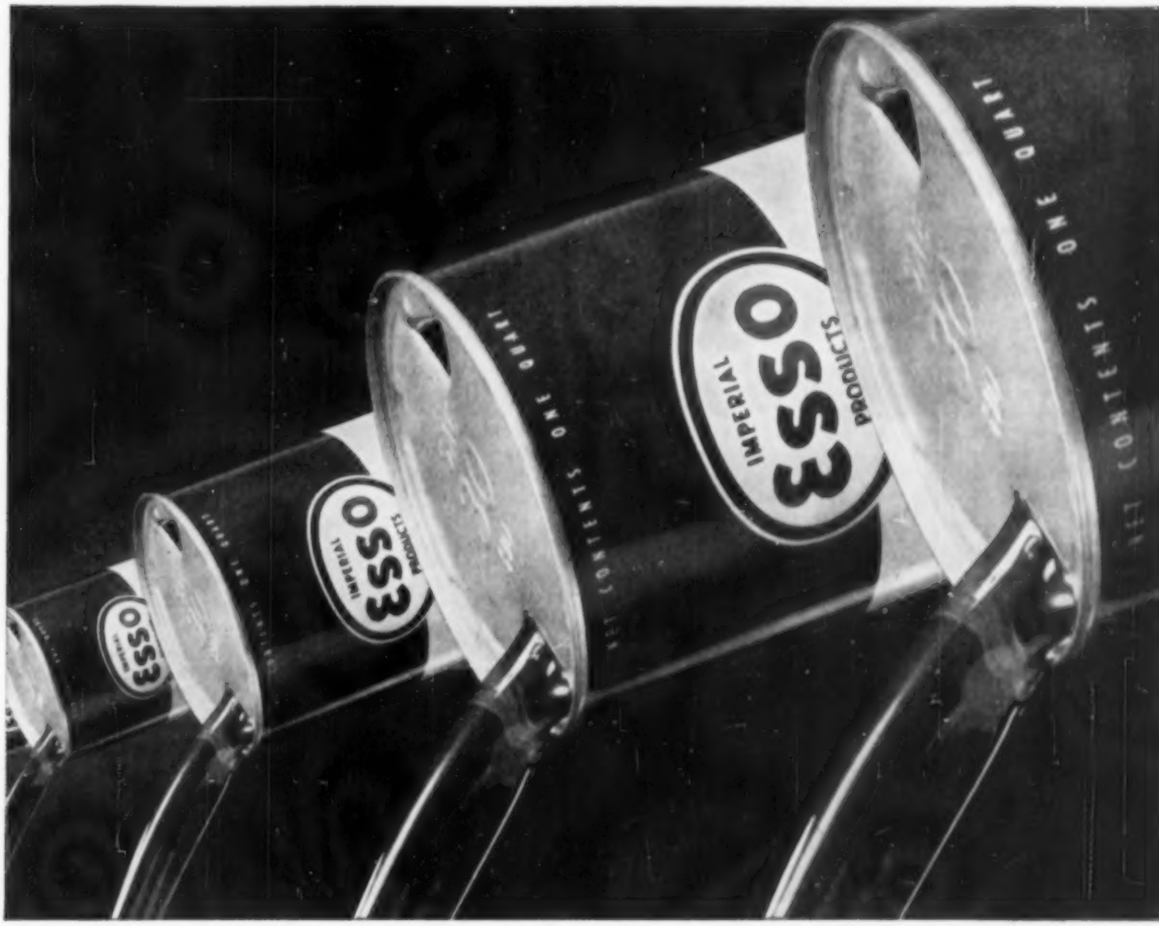
105A Dry Separation Systems. Heavy duty vibrating screens, air tables, stoners. Sutton, Steele & Steele, Inc.

107A Tower Packing Booklet. Comprehensive booklet from Harshaw Chemical Co. discusses application of Tellerettes to tower packing.

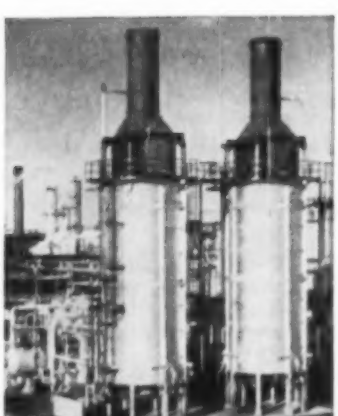
109A Control Valves. Low initial cost, low maintenance and spare parts inventory. Annin Co.

111A Tubular Products. Seamless and welded tubular products, seamless welding fittings and forged steel flanges, in carbon, alloy and stainless steel. Babcock & Wilcox Co.

(Continued on page 84)



Uniform . . . thanks to gentle heat at high temperature



Imperial Oil's massive heaters using Dowtherm provide 700°F. processing temperatures to reboilers.

For processing uniform oils, Imperial Oil Limited uses the uniform heat-transfer medium—Dowtherm!

To ensure product uniformity—such as color, odor, and response to additives—Imperial Oil Limited of Canada planned an oil processing sequence for their new lube oil refinery at Edmonton, Alberta. Their plan included a process heating system using liquid Dowtherm®, the modern heat-transfer medium.

Essentially, their choice of Dowtherm was based on its high temperature stability. But study revealed cost and operating savings as well. In addition, lower oil skin temperatures and ease of operation promised more gentle treatment of oil in process.

Processors in other industries choose Dowtherm as the ideal heat-transfer medium also, because it overcomes most of the disadvantages of other chemical mediums, hot water, direct fire and steam. In vapor systems, it provides temperatures to 750°F . . . with fraction-of-a-degree accuracy . . . at pressures below 150 p.s.i.! What's more, heat transfer is completely uniform, eliminating local overheating and underheating.

Whatever *your* product—profit by having all the facts on Dowtherm and the more compact, thinner walled equipment its low operating pressures make possible. Write THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. BD-847J-1.

YOU CAN DEPEND ON DOW

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

(Continued from page 82)

113A Employment Opportunities. Immediate openings at Chemstrand Corp., for graduate engineers in chemical, mechanical, industrial, textile, and instrument engineering.

115A Special Condensing Tower. The Convactor, made by Croll-Reynolds Co., is an entirely new design of special condensing tower which offers important advantages in many processes.

117A Bulletin and Corrosion Guide. 12-page bulletin from Electro Chemical Engineering & Manufacturing Co. describes process equipment in wide variety of corrosion-resistant materials.

118A-119A Stainless Steel Heads. G. O. Carlson, Inc. maintains large stock of A.S.M.E. and Standard flanged and dished stainless steel heads. File folder available.

121A Activated Carbon Booklet. Pittsburgh Coke & Chemical Co. offers booklet "Pittsburgh Activated Carbons" describing use in both liquid and vapor phase applications.

122L Filtration Analysis Report. Eaton-Dikeman Co. will arrange for tests of their filter papers in your own plant without cost.

123A Ethylene Oxide Plants. New $11 million ethylene oxide and glycol plant under construction by Lummus Co. for Calcasieu Chemical Corp. is the third of its type.

124L Filtration Data. Product literature from Cuno Engineering Corp. gives data on several distinct types of filter media.

125R Tantalum Test Kit. Corrosion test kit, available without charge to research technicians, contains both tantalum wire and sheet. Fansteel Metallurgical Corp.

126TL Chlorination Bulletin. Technical information from Wallace & Tiernan, Inc. on their industrial chlorination systems.

126BL Cathodic Protection Systems. Individually designed for each application to prevent corrosion of buried or submerged metal structures. Bulletin from Electro Rust-Proofing Corp.

127A Flexible Metal Hose. Consulting and design engineering services offered by Packless Metal Hose, Inc. on applications of their packless, seamless, flexible metal hose.

128L Filters. Standard ClaRite filters in three types of filter membranes, 5 to 185 sq.ft. of filtration area in carbon steel, stainless steel, or lined carbon steel. Technical data from Croll-Reynolds Engineering Co.

129R Oil Reclaimer Systems. Continuous all-electric, automatic operation, low operating temperature. Bulletin from Hilliard Corp.

131R Air-Cooled Condenser. Bulletin from Niagara Blower Co. describes their Aero Vapor Condenser, said to produce higher vacuum with economies of power and steam.

132L Heat Exchangers. Spiral and plate types available from American Heat Reclaiming Corp.

133A Employment Opportunities in Liquid Metal Engineering. Chemical, metallurgical, other engineers needed at Argonne National Laboratory.

134L Wire Cloth Reference Manual. Describes woven wire conveyor belts in any size, mesh, or weave. Cambridge Wire Cloth Co.

135R Packaged Air Heaters. Rated outputs to 20,000,000 B.t.u./hr. Thermal Research & Engineering Corp.

136L Multi-Stage Ejector. For attainment of extremely low absolute pressures. Graham Manufacturing Co.

137A Industrial Furnaces. Petrochem-Isoflow furnaces, made by PetroChem Development Co., insure uniform heat distribution, maximum fuel efficiency.

138L Small Corrosion-Resistant Pump. "Minilab" rotary pump, made by Eco Engineering Co., available in Hastelloy C and Teflon construction for applications from 0 to 2 gal./min. Complete specifications and pump curves available.

139A Diaphragm Control Valves. Available for any flow from 0 to 4,000 gal./min. Kieley & Mueller, Inc.

140L Teflon-Lined Pipe and Fittings. For pressures from full vacuum to 400 lb./sq.in., temperatures from minus 90 to plus 400° F. John L. Dore Co.

141A Porcelain Raschig Rings. Bulletin containing description and specifications. Lapp Insulator Co.

142L Exposition of Chemical Industries. The 26th Exposition of Chemical Industries will be held Dec. 2-6, 1957, at the New York Coliseum.

143A Syloids. Technical data from Davison Chemical Co. on use of syloids as flatting agents for vinyls, lacquers, and varnishes, thickening agents for resins and inks, many other applications.

144L Safety Heads. Any specified pressure from 3 to 100,000 lb./sq.in., sizes from 3/16 to 36 in. diameter, special sizes to any specification. Black, Sivalls & Bryson, Inc.

145A Leakproof Pump. Chempump combines pump and motor in single, leakproof unit. No shaft sealing required. Temperatures to 1,000° F., pressures to 5,000 lb./sq.in. Details from Chempump Corp.

147R Polymer Pilot Plants. Crawford & Russell, Inc. offers bulletin with technical discussion of polymer pilot plant design factors.

148L Vertical Industrial Pumps. Bulletin from Layne & Bowler Pump Co. gives details of new line of vertical pumps. Capacities from 20 to 3,000 gal./min., heads to 600 lb./sq.in.

149A On-Site Oxygen Generation Units. Air Products, Inc. will build, operate, and maintain oxygen production facilities on client's site without capital investment on part of client.

150BL Duplex Disperser. Produces finished homogeneous batches without further milling for majority of present inks and paints. Troy Engine & Machine Co.

151A Alloy Valves. Complete line including gates, globes, angles, checks, "Y's", relief, flush bottom tank valves—for pressures from 150 to 1,500 WP. Wm. Powell Co.

(Continued on page 86)

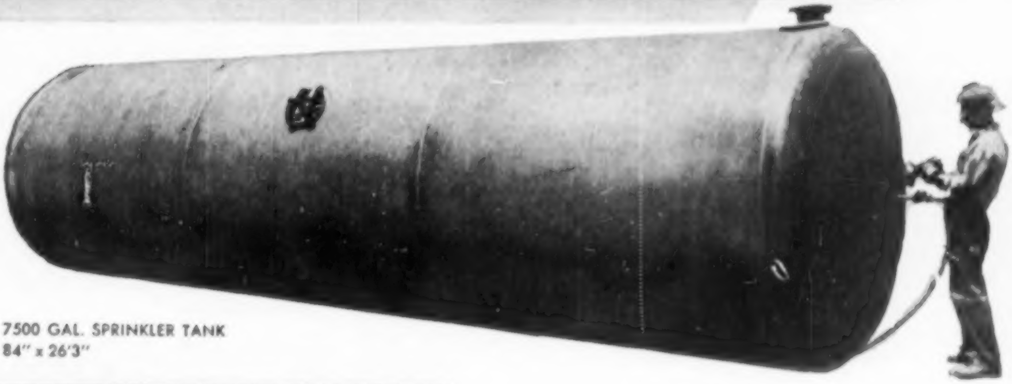
DEVELOPMENTS OF THE MONTH (*Cont.*)

635 Portable Liquid Nitrogen Refrigerator. A new unit, developed by the Linde Co., consists of a double-walled jacket of Heliarc-welded stainless steel insulated by a vacuum-powder combination. The inner container is filled with liquid nitrogen at a temperature of minus 320° F. Storage baskets filled with the material to be frozen or stored are lowered into the liquid nitrogen. The unit will then hold the material at a constant temperature of minus 320° F. A single charge of liquid nitrogen will last up to 34 days. Fully charged, the unit weighs only 115 pounds. For further information, circle number 635 on Data Post Card.

(Continued on page 86)

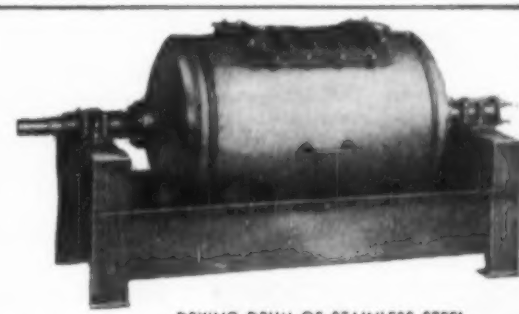
STAINLESS STEEL CONCENTRATOR WITH 7'6" OD VAPOR HEADS

76 years of KOVEN fabricating experience built into every job



7500 GAL. SPRINKLER TANK 84" x 26'3"

80' DIA. CLARIFYING TANK— FIELD ERECTED



DRYING DRUM OF STAINLESS STEEL

X-RAY INSPECTION FOR QUALITY CONTROL

KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.

SPECIALISTS IN INTRICATE FABRICATION USING:

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MONEL · NICKEL · INCONEL
ALL CLAD MATERIALS
NICKEL PLATED STEEL
FABRICATION TO ALL A.S.M.E. CODES

See Sweet's Catalog File and Chemical Engineering File

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PLANTS: JERSEY CITY, N. J., DOVER, N. J., TRENTON, N. J.

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

(Continued from page 84)

152L Spray Nozzle Catalog. Lists nozzles in complete range of sizes and capacities in brass, bronze, stainless steel or any other machineable metal. Spray Engineering Co.

153A Process Equipment. Chemical service valves, automatic filters, process pumps, heat exchangers, steam jets, tower sections, etc. Duriron Co.

154L Wire Cloth Catalog. Describes complete line of woven wire cloth and wire cloth parts in all malleable metals. Newark Wire Cloth Co.

155A Mixer data. Complete information from Read Standard, division of Capitol Products' Corp., on Readco mixers, available in capacities from 150 to 900 gal.

156L All-Plastic Gate Valve. Catalog from Vanton Pump and Equipment Corp. gives full details on new "Flex-Plug" valve. Sizes from ½ to 2 in.

157A Hydrogen-Treating Catalysts. Application, process conditions, performance features, typical specifications on G-35 hydrogen-treating catalysts given in bulletin from Girdler Co., Catalyst Dept.

158TL Adsorbents, Desiccants, Diluents. Samples and technical information available from Floridin Co., specialists in processed Fuller's earth.

158BL Engineering and Contracting Services. C. W. Nofsinger Co. are experienced engineers and contractors for the petroleum and chemical industries.

159A Sulfur. Crude sulfur in any amount, in solid or liquid form, via vessel, barge, rail, or truck. Freeport Sulphur Co.

160L Gasket Catalog. Chemiseal gaskets with a variety of filler constructions to suit every connection problem. United States Gasket Co.

161A Oxygen Generation Facilities. Linde Co. will build, operate, and maintain oxygen and nitrogen production facilities at your site. No capital investment on part of user, guaranteed price for oxygen.

164L Process Equipment Catalog. Describes complete Hardinge Co. line—grinding mills, dryers, coolers, feeders, kilns, air classifying systems, etc.

165A Design and Construction Services. When considering expansion—"the most important investment you can make is in the creative ability of men." Fluor Corp.

166L Filter Medium. Palmer Filter Equipment Co. offers technical information, recommendations, and quotations on "Anthrafilt" filter medium.

166BR Corrosion - Resistant Centrifugal Pumps. Catalog and performance curves on the Flex-Seal centrifugal pump, made by Bart Manufacturing Corp.

167BL Radioactive Waste Disposal. Complete sea disposal of radioactive wastes, pyrophoric materials, other dangerous and toxic materials. Crossroads Marine Disposal Corp.

167R Wood Processing and Storage Equipment. Chemical equipment bulletin from Wendnagel & Co.

168A Crystallizer Bulletin. 20-page descriptive bulletin from Struthers-Wells Corp. gives operating data, recommended applications, technical details on Krystal crystallizers.

169R Spiral Blade Mixer. Smooth, intimate blend without pile-up. Catalog from Paul O. Abbe.

171A Three-Stage Ejector. Engineering data offered by Elliott Co. covers complete range of steam jet ejectors including single-stage, special corrosion-resisting, and various multi-stage types.

172L Self-Balancing Indicator-Controller. For measurement and control of solution concentrations not requiring recording. Catalog from Industrial Instruments, Inc. covers complete line of conductivity cells and instruments.

172BR High-Purity Fused Quartz. Data file on high-purity fused quartz and fused silica. Amersil Co.

173BL Processing Equipment. Dryers, coolers, ammoniators, granulators, elevators, conveyors. Edw. Renneburg & Sons Co.

173R Grinding Equipment. Bulletins from Pulva Corp. describe the Pulva-Sizer, a high-speed hammer mill, and the Com-Bin Feeder, a combination surge bin and feeder.

174L Spray Dryers. Nerco-Niro Spray Dryer Div., Nichols Engineering & Research Corp. will have experienced spray-drying engineers available for discussion at their booth at the Chemical Industries Exposition, New York Coliseum, Dec. 2-6, 1957.

175R Rupture Disk Catalog. Describes Impervite rupture disks, available in diameters from 2 to 24 in. for pressures from full vacuum to 250 lb./sq.in. at temperatures to 650° F. Falls Industries, Inc.

176L Tubing Catalogs. Seamless and welded and drawn stainless steel tubing, mechanical, capillary, hypodermic, aircraft, nickel and nickel alloy tubing, tubular fabricated parts. J. Bishop & Co. Platinum Works.

176BR Standardized Rotameters. New interchangeable float brings new simplicity to rotameter instrumentation. Bulletin from Brooks Rotameter Co.

177L Water Stills. Bacteria and organic-free still, automatic stills, new catalogs, from Barnstead Still & Demineralizer Co.

177R Filtration Catalog. Describes line of filter presses made by D. R. Sperry & Co.

178L Vibratory Feeders. Syntron vibra-flow vibratory feeders assure smooth, even bulk materials flow, with variable control. Complete catalog from Syntron Co.

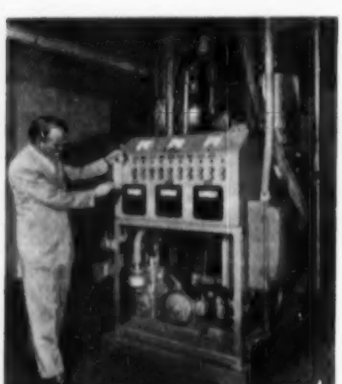
179TR Graphite Burst Discs. Replaceable discs, mounted in permanent holders. Burst pressures from 5 to 75 lb./sq.in. Accurate to plus or minus 5% of rated burst pressure. Sizes from 2 to 6 in. Delanium Graphite Co.

179BR Block Type Graphite Heat Exchangers. Sixteen models available with heat transfer areas from 4 to 200 sq.ft. Compact construction minimizes space requirements, permits operating pressures of 100 and 200 lb./sq.in. Delanium Graphite Co.

180L Counterflow - Regenerated Ion - Exchangers. Ion leakage said to be reduced to about ⅓ of usual amount. Illinois Water Treatment Co.

180BR Germanium Rectifiers. Complete rectification "packages" for operation of electrolytic cells. Technical literature from Sel-Rex Corp.

(Continued on page 88)



DEVELOPMENTS OF THE MONTH (*Cont.*)

636 Molecular Distillation Test Runs. Arthur F. Smith Co. announces that one of its Model "700" pilot molecular stills is now available for test runs and limited custom distillation. The high vacuum molecular still, located at the firm's plant in Rochester, N. Y., is capable of feed rates up to 150 lb./hr., and can process organic compounds with molecular weights to 1,250, and silicones and halocarbons to 4,000. Cost of pilot runs or tests of customer's material is $125.00/day. Distillation is handled by a highly-skilled team of engineers. Further details and scheduling of tests may be obtained from Arthur F. Smith Co.

PRODUCTS ADVERTISED IN THIS ISSUE (Cont.)

(Continued from page 86)

181TR Portable Mixer Bulletin. 1/20 to 5 hp. with a variety of speeds and motor enclosures. Eastern Industries, Inc.

181BR Adjustable Sprocket Rim. The Babbitt adjustable sprocket rim with chain guide allows operation of every valve from plant floor. Descriptive catalog sheet and prices from Babbitt Steam Specialty Co.

182BL Electronic - Controlled Laboratory Stirrer. Speed on direct drive ranges from 400 to 5,000 rev./min. in stepless control. Data from Ace Glass, Inc.

183A Batch Filters. Vertical leaf, vertical batch, horizontal, cartridge filters. Illustrated bulletins from Process Filters, Inc.

184L Fused Silica Laboratory Ware. Crucibles, evaporating dishes, tubing and rods in all diameters and sizes. Bulletin from Thermal American Fused Quartz Co., Inc.

184R Process Equipment. Mechanical and heat transfer equipment, including custom designing and foundry service. Goslin-Birmingham Manufacturing Co.

185L Thermocouple Wire. Bulletin from Claud S. Gordon Co. gives specifications and data on Serv-Rite thermocouple wire and extension wire.

185R Centrifugal Pump Bulletin. Bulletin from Frederick Iron and Steel, Inc. describes enclosed and open impeller types. Capacities from 50 to 700 gal./min. Heads from 30 to 220 ft.

186L Plastic Ventilating and Exhaust Systems. Full technical details from American Agile Corp. on Agilene and Agilide corrosion resistant exhaust systems.

186BL Process Equipment. Condensers, evaporators, kettles, ribbon mixers, agitators, reactors, pressure vessels, heat exchangers, reboilers. Manning & Lewis Engineering Co.

187BL Industrial Irritant Protection. Ayerst Laboratories offer full information on "Kerodex" barrier creams for skin protection.

GRAPHITE HEAT EXCHANGERS

(Continued from page 77)

Operation of the polybloc exchanger is based on two main principles: fluid flow is through short passages providing continuous turbulence for highest possible heat transfer; use of molded graphite blocks with correct orientation of the crystals gives maximum thermal conductivity. Further technical details are contained in a bulletin from the manufacturer. Circle number 631 on Data Post Card.

187R Multi-Wash Collectors. For gas cooling and condensing, profitable by-product recovery. Claude B. Schneible Co.

188TL Tankometer. For measuring tank contents from any distance away. Also hydrostatic gauges for all purposes. Uehling Instrument Co.

188BL Technical Data Books. Free catalogs from Lefax Publishers list more than 2,000 pocket-size, loose-leaf technical data books.

188BR Process Equipment. Presses, granulators, ovens, mixers, punches, dies, fillers. Arthur Colton Co.

189BL Grinding Bulletin. Describes full line of attrition mills, breakers, crushers, hammer mills, granulators, classifiers, etc. Bauer Bros. Co.

189TR Corrosion-Resistant Pipe and Tubing. For operation up to 1,000 lb./sq.in. and temperatures to 250° F. Fibercast Corp.

189BR Corrosion-Proof Pump. Capacities from 0.2 cc./min. to 4.5 gal./min. Catalog from Sigmamotor, Inc.

> O **CIRCLE** *your Data Service requests on the handy postcard on page 78 to*
>
> ▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

190TL Solids Meter. New Vibra Screw meters solids like liquids. Continuous flow rates from 1 oz. to 100 tons/hr. Vibra Screw.

190BL Spray Nozzle Catalog. Nozzles cast or machined from standard or special corrosion-resistant metals and materials. Binks Manufacturing Co.

191TR Heatless Air Dryers. Complete line of electric or steam regeneration dryers—automatic, semi-automatic, or manual operation. Operating pressures to 5,000 lb./sq.in. Technical literature from Kahn and Company, Inc.

191BR Tower Packings. Raschig rings, single-partition rings, cross-partition rings, Berl saddles. Knox Porcelain Corp.

194L Plastic Pipe. Brochure from Kraloy Plastic Pipe Co. gives details on Kraloy PVC plastic pipe and Kraloy PVC high impact plastic pipe and tubing.

195T Pressure Vessels. All types and sizes, steel or alloy steel, for liquid or gas. Posey Iron Works, Inc.

195BL Castings. A special pump case made of Hi-Tensile iron is typical of accurate and economical castings produced by Kutztown Foundry & Machine Corp.

195BR Ejectors. To create vacuum, increase pressure, and to mix gases. No moving parts. Ingersoll-Rand.

196BL Low Temperature Separation Plants. For production of nitrogen, argon, ammonia synthesis gas, methanol synthesis gas, ethylene, ethane, methane, carbon dioxide. Gesellschaft fuer Linde's Eismaschinen A. G.

196BR Stainless Pipe and Tubing. Illustrated catalog and data tables from Swepco Tube Corp.

197T Electric Distributor. For push button control in distribution of dry bulk materials. Hayes & Stolz Industrial Manufacturing Co.

197BL Portable Small Capacity Filters. For small batches where sludge or filter aid is required. Ertel Engineering Corp.

197BR Rotameters and Flow Indicators. Bulletin from Schutte and Koerting Co. lists complete line available from stock.

198TL Nuclear Services. Comprehensive, integrated service for development of peaceful uses of atomic energy. Astra, Inc.

198BL Thermo-Panel Coil. The Dean Thermo-Panel Coil can replace pipe coils with advantage in many applications. Complete engineering and price data from Dean Thermo-Panel Coil Division, Dean Products, Inc.

199TL Flexible Hose. Catalog from Flexaust Co. shows new industrial applications of Flexaust hose and Portovent retractable ducts.

199BL Self-Aligning Coupling. New smooth seal, self-aligning coupling can be installed in 15 minutes or less. For light-wall stainless pipe lines. Swepco Fittings, Inc.

199R Chemical Processing Machinery. Mixers, kneaders, etc. Complete technical information from Charles Ross & Son Co.

200BL Precision Bore Tubing. Square, rectangular, hexagonal, tapered. Available in Pyrex, Vycor, most electronic glasses. Detailed catalog from Wilmad Glass Co.

200BR Bin Level Indicator. Bulletin from Bin-Dicator Co. describes features of the improved Roto-Bin-Dicator.

201TL Spray Nozzle Selection Guide. 48-page catalog from Spraying Systems Co. gives complete performance data.

201BL Welded Aluminum Tanks. For storage, pressure vessels, and processing equipment. Built to A.S.M.E. Code specifications. R. D. Cole Manufacturing Co.

201R Uninclosed Motors. U.S. Electrical Motors offers their Type H uninclosed motor. Permits more horsepower in a smaller package. Bulletin.

IBC Diaphragm Pump and Polar-Crank Drive. Will meter liquids accurately against pressures to 2,000 lb./sq.in. Rates to 400 gal./min. Milton Roy Co.

OBC Mixer Bulletins. Technical and design data in several bulletins from Mixing Equipment Co.

CEP'S chemical engineer's guide to the

26th EXPOSITION OF CHEMICAL INDUSTRIES

The Chem Show returns to New York bigger, more comprehensive, than ever before. That's the interpretation *CEP*'s editors came up with in previewing the exhibits for the directory which follows.

Always educational, always a source of contacts with the experts, the Exposition's 26th affair is expected to surpass those of the past in many respects. One of these will be the emphasis on the technical backgrounds of the more spectacular equipment development and building accomplishments.

The Exposition will feature many examples of automated processing operations; several will incorporate new applications of fundamental phenomena. Included will be a control panel for batching and proportioning liquids and solids in response to punched card instructions, plus many other exhibits of advanced, yet practical, concepts.

In *CEP*'s Directory of Exhibits which follows, the abbreviated format employs this sequence:

• Booth number (correlates with floor-plan diagrams). • Company name and location. • Major products plus items featured in exhibit (when made available to CEP). • Key personnel (available through booths).

1302 A.P.V. Co., Inc., Buffalo, N. Y.

836 Adams Company, Inc., R. P., Buffalo, N. Y. Porous stone filters; sample filtration system. R. P. Adams, P.; L. M. Rawlings; and sls. engrs.

365 Aetna Scientific Company, Everett, Mass. Laboratory water stills and sterilizers, featuring automatic temperature and pressure controls. W. L. Putnam, plt. mgr., and F. T. Siragusa.

841 Airetool Mfg. Co., Springfield, Ohio. Air-powered tube and condenser cleaners, tube cutters and expanders, and pneumatic production equip. W. T. Hamilton, P.; I. T. Thornton, sls. mgr.; E. Krantz, T. Brandon, J. O'Leary.

465 Alberene Stone Corp. of Virginia, New York, N. Y. Stoneware lab equip.

569 Allegheny Ludlum Steel Corp., Pittsburgh, Pa. S. S. plate and tubing for atomic energy and chem. fields.

1359 Allen-Scherman-Hoff Co., Wynnewood, Pa. Rotary feeders; samples of universal-slide and feed-check valves. W. Mather.

955, 957, 959, 1439 Allied Chem. & Dye Corp., New York, N. Y. Broad line of chemical materials.

636 Allis-Chalmers Mfg. Co. Milwaukee, Wis. Motors, pumps, Texrope V-belt drive equipment, electro-chem. proc. equip., feature cont. compacting proc. fine mesh mtls. A. J. Cooper, N. W. Landis, D. A. Wooley, dist. mgrs.; and J. L. Bertoli, W. J. Brennan.

100 Allis Co., The Louis, Milwaukee, Wis. Electric motors. Feature submersible, hollow-shaft, and synchronous induction motors. J. W. Allis, P.; C. G. Skidmore, W. F. Schrieber, F. G. Luber, W. E. Barta.

1067 Alloy Fabricators Div., Continental Copper & Steel Industries Inc., Perth Amboy, N. J. Corrosion resistant proc. equip.

1167, 1169 Alloy Prods. Corp., Waukesha, Wisc.

22 Alloy Steel Products Co., Linden, N. J. Corros. resist. valves; feature size range and material availability. R. M. Davis, P.; H. C. Templeton, R. E. Bolle Jr.

1274 Alpha Plastics Inc., Livingston, N. J. PVC pipe, valves, and fittings; feature PVC drainage system to handle corrosive liquid waste. C. E. Harrader, P.; T. F. Long, VP.

381 Alsop Engineering Corp., Milldale, Conn. Portable filtration. S. S. tanks. C. E. Crowley, bd. chmn.; S. Alsop, P.; H. Eustis, H. Popp.

559 Aluminum Co. of America, Pittsburgh, Pa. Corros. resist. construction mtls.

676 American Air Filter Co., Inc., Louisville, Ky. Filtering and dust control equip, heating and ventilating equip.

1056-8 American Heat Reclaiming Corp., New York, N. Y. Heat exchangers, feature spiral and plate types. J. J. Sheridan and staff.

1126 American Gas & Elect. Service, New York, N. Y.

833 American Gas Furnace Co., Elizabeth, N. J. Natural gas and air burners, indust. heat treating.

1161 American Hydrotherm Corp., L. I. City, N. Y. Thermal engrs. & consultants; feature high temp. heating and cooling systems. B. S. Breitman, A. Bellac, J. Pullman.

456, 506, 556 American Machine & Metals Inc., E. Moline, Ill. (See Tolhurst Centrifugals & Niagara Filters).

1282, 1284 American Plant Equip. Co., Elizabeth, N. J. Pressure leaf filters, resin treated filtration fabrics.

190, 192, 196, 225 American Platinum Wks., The, Newark, N. J. Rare metals ware, catalysts & chemicals.

862 American Tool & Machine Co., Boston, Mass. Basket centrifugals.

366 American Sterilizer Co., Erie, Pa. Sterilizers, surgical tables, lights; Cry-O-Therm cold gas sterilizer. E. Berry, div. mgr.

1390 American Well Works, Aurora, Ill. Pumps, water conditioning, and waste treatment equip.; feature pilot plant size Homomix cont. mixer. H. W. Hauser, dev. engr.

190, 192, 196, 225 Amersil Co., Inc., Milwaukee, Wisc. Fused quartz pipe ware.

412 Ampco Metal Inc., Milwaukee, Wis. Aluminum-bronze corros. resist. alloys; feature Ampco Metal, Grade-8, which inhibits stress-corrosion cracking w/o heat treatment. R. Severson, J. Marischen, J. W. Nebel.

314 Analytical Measurements Inc., Chatham, N. J. pH meters. F. G. Paully, P.; K. J. Lesker.

1265 Anderson Co., The V. D., Div. of International Basic Economy Corp., Cleveland, Ohio. Centrifugal entrainment separators, steam traps.

175 Andrews-Knapp Construction Co., Inc., L. I. City. Homogeneous lead clad proc. equip. A. P. Knapp, P.; J. E. English, J. E. Ewing.

95 Ansul Chemical Co., Marinette, Wis. Chemical products, dry chemical and water fire extinguishing equip.; feature nitrogen hetro-cyclic products. L. C. McKesson, VP.; F. W. Wedge, Jr., others.

1383 Applied Research Laboratories, Glendale, Calif. Spectrochemical equip.; feature Quantrol X-ray fluorescence instrument for non-destructive production-line analysis. P. S. Goodwin, syst. div. mgr.; B. R. Boyd, H. W. Calkins, J. E. VanDien, J. W. Anderson.

1079 Arenco Machine Co., Inc., New York, N. Y. Bottle and tube filling & packaging machy.

1221, 1223 Armco Steel Corp., Middletown, Ohio. Iron & steel plates, sheets, strips, coil wire, etc.

874 Artisan Metal Products, Inc., Waltham, Mass. Engrg. and mfg. special equip. for process industries. C. W. Angell, L. J. Monty, K. Berrian, A. Gudheim.

1417 Arwood Precision Casting Corp., New York, N. Y. Precision castings, ferrous & non-ferrous alloys.

898 Assoc. Cooperage Indus. of America, St. Louis, Mo. Trade assoc. of wooden barrel indus. A. H. Knapp, exec. dir., and staff.

1424, 1426 Atlantic Research Corp., Alexandria, Va. R&D consultants; feature rockets, rocket fuels, and testing devices. DeW. O. Myatt, mgr. of dev.; D. A. McBride, G. E. Pierce, R. Talton.

884, 886 Aurora Pump Co. (subsid. N. Y. Air Brake Co.), Aurora, Ill. Centrifugal and turbine type pumps. G. W. Anderson, div. sls. mgr.; J. Bals, C. Swenson.

346 Autoclave Engrs., Newark, N. J. Lab. pilot plant high press. equip.

26th EXPOSITION OF CHEMICAL INDUSTRIES

847 Automatic Switch Co., Florham Park, N. J. Solenoid operated valves, automatic transfer switches, electromagnetic control. W. F. Hurlburt Jr., P; R. McCormick, F. P. Spinelli, R. May, T. Hacker, J. Platt.

1134, 1136 Automotive Rubber Co., Inc., Detroit, Mich. Rubber coatings for process equip.

660 B-I-F Industries Inc., Providence, R. I. Liquid proportioning pumps, flow-tubes for fluid flow metering.

1002, 1004, 1006 Babcock & Wilcox Co., The, Tubular Prods. Div., Beaver Falls, Pa. Seamless & welded carbon alloy & SS tubing & piping.

45 Bailey Meter Co., Cleveland, Ohio. Meters and control systems; feature Performance Monitor. F. H. Fellows, mgr.; E. B. Bossart, R. S. Darke.

190, 192, 196, 225 Baker & Co., Inc., Newark, N. J. Precious metal catalysts, ware & rupture discs.

560, 609 Baker Perkins Inc., Saginaw, Mich. Mixing and kneading machy. for chem. proc. ind.; emphasis on large scale machy.

1374 Barber-Colman Co., Wheelco Instr. Div., Saginaw, Mich. Industrial instruments.

439 Barco Mfg Co., Barrington, Ill. Ball joints for pipe lines.

1035 Barish Pump Co., Inc., New York, N. Y.

52 Barneby-Cheney Co., Columbus, Ohio. Activated charcoal, purification and recovery equip.

416 Barnstead Still & Demineralizer Co., Boston, Mass. High purity water still, water tester, U-V water sterilizer. D. G. Miller, A. White, S. Atkins.

127 Barrett-Cravens Co., Northbrook, Ill. Fork & lift trucks, indus. tractors.

1341 Bart Manufacturing Corp., Belleville, N. J. Electro-plated nickel pipes, fittings, sheet & plate.

21 Belmont Packing & Rubber Co., The, Phila., Pa. Mechanical packings, asbestos, rubber, metal gaskets.

333 Beckman Instruments, Inc., Process Instruments Division, Fullerton, Calif. Inst. for proc. anal. control; feature instr. for lab. & indus. use. W. Rianda, J. Maypenny, M. K. Howlett & staffs.

1098 Bel Art Products, West New York, N. J. Plastics for science and ind.; feature polyethylene ware. K. Landsberger, P.; G. McClure, G. Tacopina.

166 Bemis Bros. Bag Co., St. Louis, Mo. Plastic, paper, cotton, burlap, & waterproof laminated textile bags.

68 Berger Mfg. Div., Republic Steel Corp., Canton, Ohio.

340 Bethlehem Apparatus Co., Inc., Hellertown, Pa. Glassworking equip. for lab. & ind., mercury cleaning appar.; feature Polymix burners for production. C. W. Nieman, P.; J. B. Lawrence, VP.

(Continued on page 92)

26th EXPOSITION OF CHEMICAL INDUSTRIES

1253 Bisch Industries Inc., Cranford, N. J.

685 Bird Machine Co., So. Walpole, Mass. Centrifugal vac., and leaf-press. filters, centrifuges; feature comprehensive range of solid/liquid separating equip. G. Sherrerd, VP.; C. A. King, H. H. Shepherd, E. G. Piper.

900, 902 Bishop, J. & Co., Malvern, Pa. Fabricated platinum and platinum alloys, feature clad metals, composite wires and sintered precious metals. D. E. Lundy, L. Moules and others.

1378 Bishopric Prods. Co., The, Cincinnati, Ohio. Steel plate fabricators, tanks, hoppers, vats, etc.

1319 Black Prods. Co., Chicago, Ill. Fndry core compounds, facings.

669 Black, Sivalls, & Bryson, Inc., Kansas City, Mo. Liquid level and press. control systems, feature controllers, transmitters, safety heads. C. T. Tonkin, R. H. Wheeler, J. F. Myers, A. R. Huse, A. Lyon, W. Whetstone.

581 Blaw-Knox Co., Pittsburgh, Pa. Design and build proc. ind. plants. Feature Nauta Mixer for quick dry mixing. W. C. Snyders Jr., P.; W. Rodgers, G. E. Kopetz.

325 Blickman Inc., S., Weehawken, N. J. Fabricated alloy vessels for proc. ind., feature lab. equip. B. Blickman, T. Anker, B. L. Becker, T. B. Lanahan.

68 Bolt & Nut Div., Republic Steel Corp., Cleveland, Ohio. (See Republic Steel Corp.)

706 Bowen Engineering Inc., No. Branch, N. J. Spray drying equip., feature diversity and large tonnage capacity dryers. D. A. Smith, VP.; W. T. Powers.

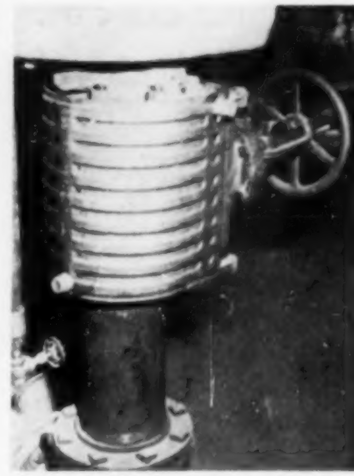
37 Brabender Corp., Rochelle Park, N. J. Instr. for research and plant control, feature cont. automatic rapid moisture recorder.

342 C. W. Brabender Instruments Inc., So. Hackensack, N. J. Measurement and control of viscous, elastic and plastic mtls., feature rheometer, viscograph and similar equip. C. W. Brabender, P.; A. O. Schmitz, & W. T. Blake VP's.; Mrs. M. Brabender, Treas.

1349, 1351 Bragar Co., Inc., Norman, Newark, N. J. Sls. reps. for: Scam Instr. Co. mfgs. modular annunciator; Hope Elect Prods. Co. explosion-proof enclosures, starters & circuit breakers; Conax Corp., explosive valves, hi-temp. & press. thermocouples; West Intr. Corp. transistorized recording potentiometer. Reps. of each mfgr.

187 Bramley Machy. Corp., Edgewater, N. J. Process mixer-dispenser-kneader.

360 Brinkman & Co., C. A., Great Neck, L. I. Lab balances and other equip., feature automatic photomicroscope, extremely accurate measuring and control devices. C. A. Brinkman, P.; sls. staff.

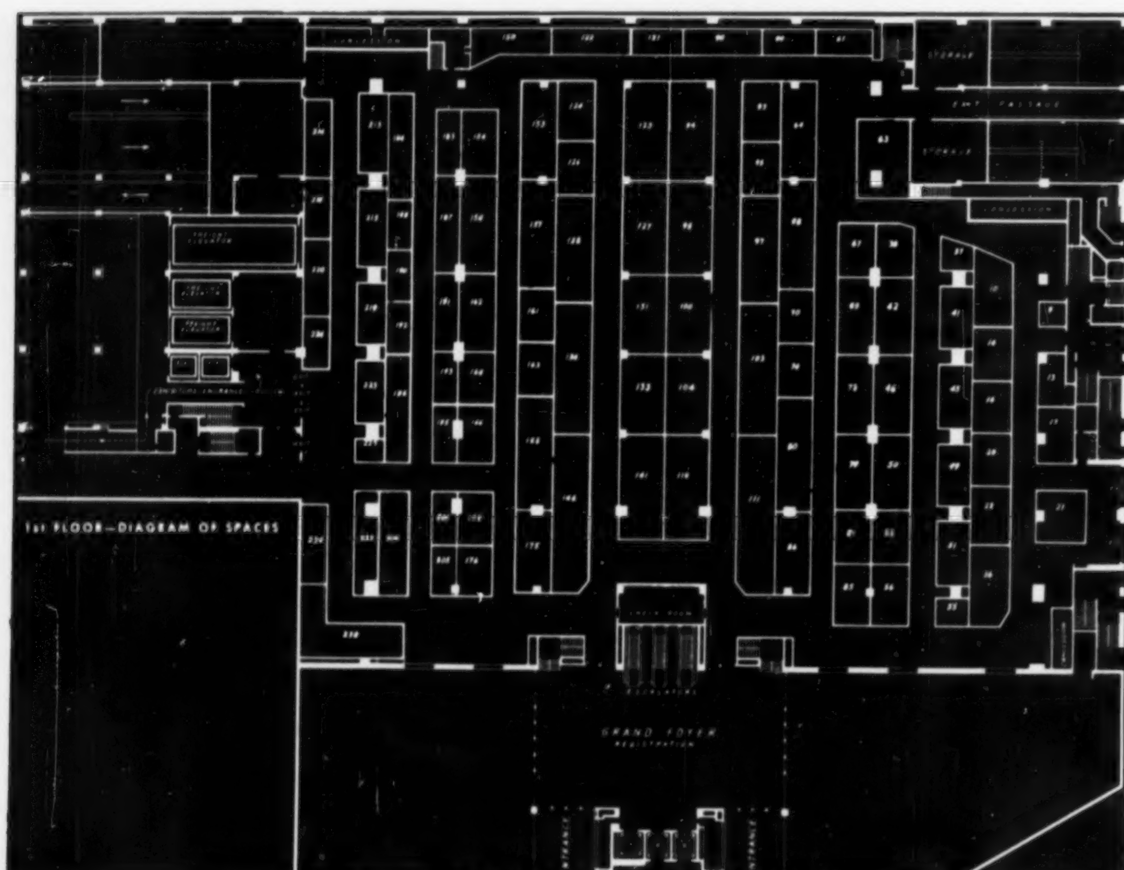


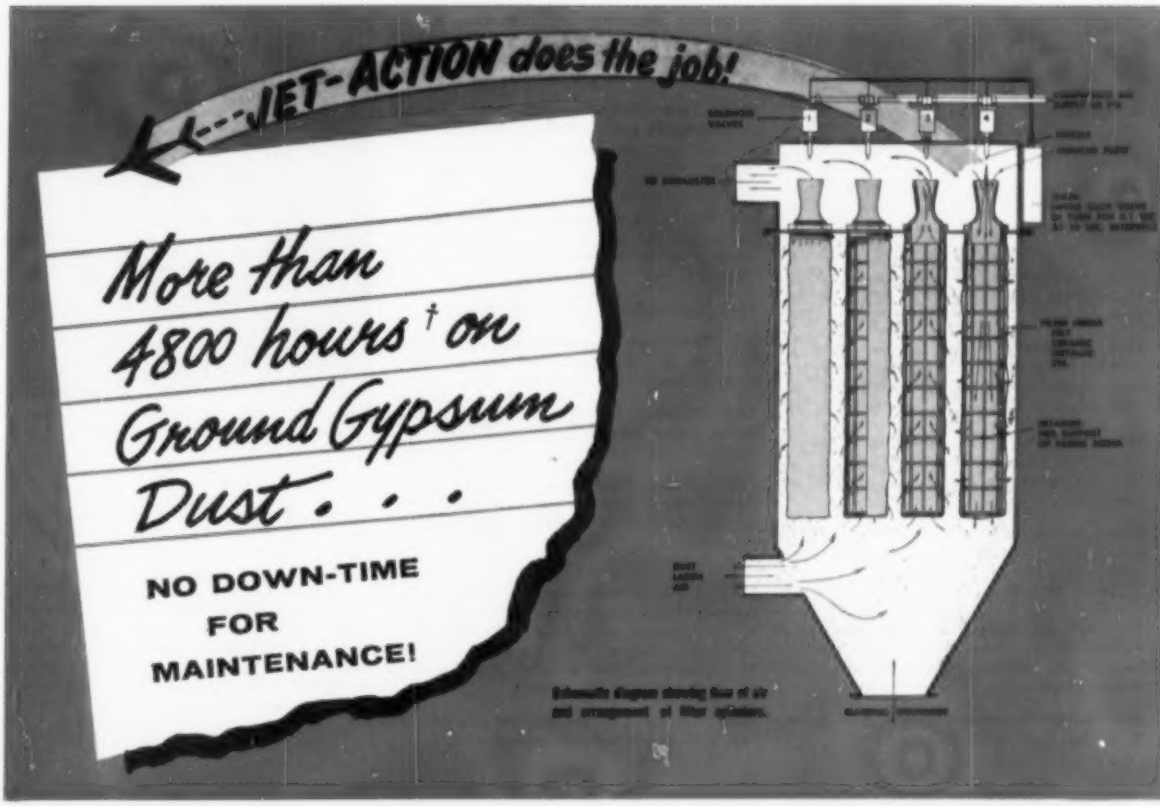
Valve warmer: Dean Thermo-Panel Coil Div., Dean Products, Inc., Booth 184.

885, 887 Brookfield Engrg. Labs. Inc., Stoughton, Mass. Automatic viscosity controls, lab mixers.

998 Brooks Rotameter Co., Lansdale, Pa. Full-view indicating rotameters, fluid flow transmitters, feature Transi-Twins flow transmitting instr. D. N. Brooks, P.; S. Blechman & N. S. Brooks.

(*Continued on page 94*)





The MIKRO-PULSAIRE* COLLECTOR!

Here is the amazing story of a typical MIKRO-PULSAIRE installation . . . no maintenance down-time in more than six months of 24-hour, six-day-a-week operation on tough ground gypsum dust! That's because the revolutionary *jet-action* cleaning principle eliminates trouble by eliminating the gears, cams, chains and hoses of the conventional filter type unit! With no internal moving parts, and with continuous automatic cleaning, the MIKRO-PULSAIRE provides *true economy* in operation . . . at a filtering efficiency of 99.9% *plus!* There's a unit designed for every collection job. ***Bulletin 52A*** gives full particulars—it's yours for the asking.

We'll be glad to have the Mikro Man call to show you and your plant engineers the tremendous advantages of MIKRO-PULSAIRE.

† at the time this advertisement was prepared
* patents applied for

The Mikro-Pulsaire offers these advantages:

- **No internal moving parts**
- **Continuous, automatic cleaning**
- **Maintenance practically nil**
- **No shaking or frictional action**
- **Low power requirements**
- **Efficiency— 99.9%+**
- **Operating temperature limited only by available filter fabrics**
- **No primary collector required**
- **Suitable for special conditions**
- **High filter ratio**

Model 48-6 MIKRO-PULSAIRE—340 sq. ft. of filter area—capacities 2000-5000 cfm. Modular construction permits selecting a unit for just about any dust collection job.

Mikro-D PULVERIZING MACHINERY DIVISION
METALS DISINTEGRATING COMPANY INC.
32 Chatham Rd., Summit, New Jersey

Visit the MIKRO Exhibit Booth 632, Chemical Industries Exposition, New York Coliseum, Dec 2—6, 1957

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1093 Brown, Judson G., Wakefield, Mass. Reversible filtration proc. completely automatic; feature working model. Judson G. Brown.

1156 Browne-Morse Co., Muskegon, Mich. Engineering, mfg. & install of lab furniture & equip.

1040 Bucket Elevator Co., The, Summit, N. J. Conveyor elevators for proc. ind., feature easily disassembled sanitary ss elevator. J. S. Adey Jr.; J. T. Collins.

937 Buffalo Meter Co., Buffalo, N. Y. Indus. liquid flow meters, featuring displacement type meters. H. F. Barrett, sls. mgr. & W. G. Carter, asst.

1376 Buffalo Wire Works Co., Buffalo, N. Y. Indus. wire and wire prods., feature indus. wire cloth. C. F. Scheeler Jr., P.; J. M. Scheeler, VP.; W. F. Scheeler.

581 Buflovac Equip. Div., Blaw-Knox Co., Buffalo, N. Y. Chem. proc. equip., flakers, evaporators, classifiers, preheaters, sterilizers, coolers, dryers.

660 Builders-Providence Inc., Providence, R. I. (See B-I-F Industries.)

9 Burling Instrument Co., Chatham, N. J. Temp. controls and equip., feature indust. temp. controls and limit switches. H. S. Burling, H. S. Burling Jr., R. G. Ford.

1358, 1360 California Pellet Mill Corp., Crawfordsville, Ind. Pellet mills for proc. ind. and lab use; feature lab mill and sample pelleted mtls. C. N. Hultberg, VP.; P. J. Husting.

918, 920 Callery Chemical Co., Pittsburgh, Pa. Boron and derivatives, feature developments in boron technology. W. H. Schechter, VP; G. F. Huff & E. B. Ayres.

1443 Cambridge Corp., Lowell, Mass.

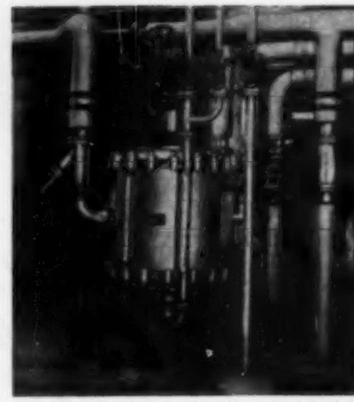
376 Cambridge Instrument Co., Inc., New York, N. Y. Precision electrical and mechanical measuring instruments.

1062 Cameron Iron Works, Inc., Houston, Texas. Indus. non-lubricated plug valves. R. Zorn, dist. sls mgr; J. Oliver, W. E. Wagner.

803 Carbone Corp., The, Boonton, N. J. Carbon prod., feature Polybloc impervious graphite heat exchanger, impervious graphite rupture discs. E. P. Eaton Jr., P.; M. J. Winson, R. L. Seidler.

1222, 1224 Carborundum Co., The, Carborundum Metals Co., Division of, Niagara Falls, N. Y. Ceramic and refractory prods. and zirconium, feature first comm. Zr equip. N. C. Bartholomew, VP.; H. A. Andersen, W. T. Stephens, A. T. McCord.

1255 Carlisle Gas Burners, Millville, N. J. Lab & shop gas burning apparatus.



Spiral heat exchanger: American Heat Reclaiming Corp., Booths 1056-8.

1230, 1232 Carpenter Steel Co., Alloy Tube Div., Union, N. J. Supply welded SS and high alloy tubing and pipe, feature new mtl. P. L. Coddington, Gen. mgr.; W. R. Staples.

1321, 1323, 1325, 1327 Carrier Conveyor Corp., Louisville, Ky. Vibrating spiral, heating conveyor, vibrating cooler, mech. variable rate feeder, feature vibrating "air slide." R. M. Carrier Jr., P.; J. M. Morris, VP.; R. W. Evans, J. Chahbandour.

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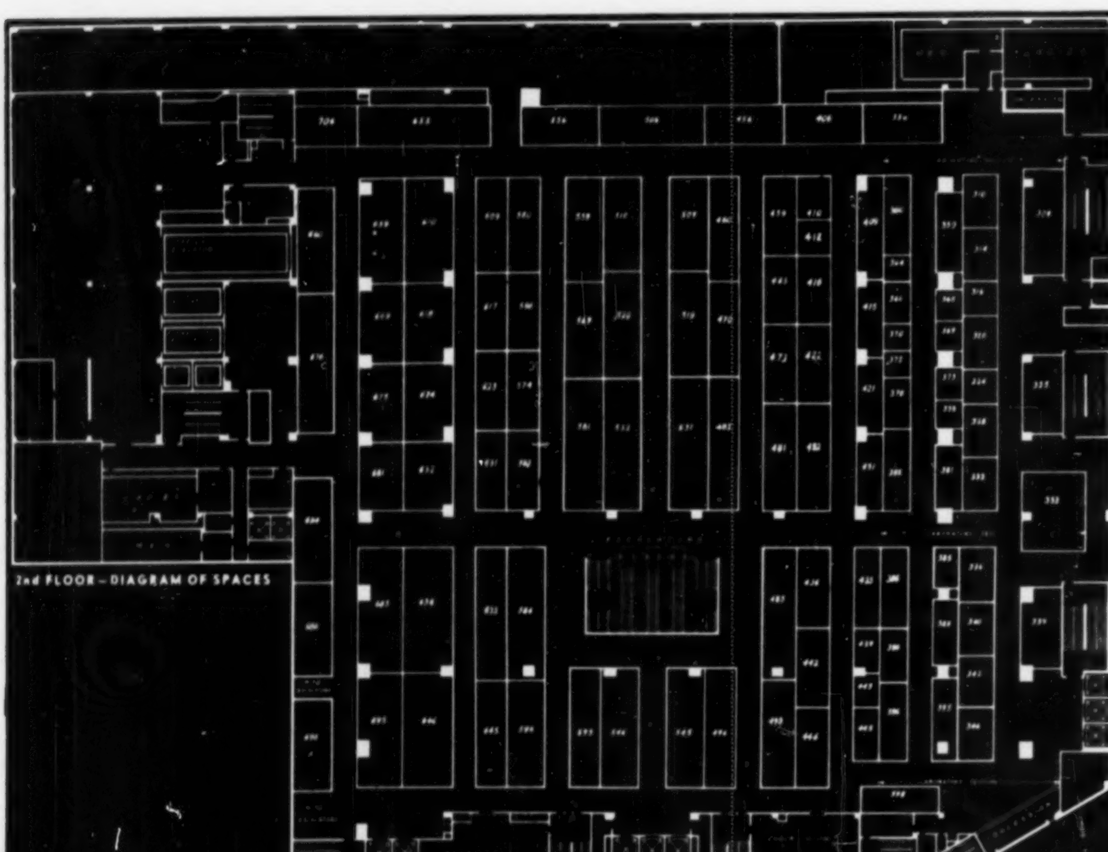

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90 Carver Inc., The Fred S., Summit, N.J. Hydraulic filtration equip. and low temp. drying proc.; feature crystallization, separation and drying proc. W. S. Carver, P.; K. A. Topps, VP.; R. W. Carver.

1165 Catalytic Combustion Corp., Detroit, Mich. Catalytic-oxidation removal of fumes, gases, odors.

842 Centrico Inc., Englewood, N. J. Jet-O-Matic nozzle separator for pilot plant work, pilot plant "De-Sludger" for liq/liq separation, counter-current extraction. J. Spiekerman, Secy.; C. H. Maass, sls mgr.; P. Stahl.

802 Chemical & Indust. Corp., The, Cincinnati, Ohio.

1064 Chemical & Pharmaceutical Ind. Co., Inc., New York, N. Y. Agents for pharmaceutical mfg. equip.; feature "Erweka" all-purpose unit, electric universal thermometer, 2-color ampoule printer, suppository wrapping mach., capsule-filling mach., 3-roller ointment mills. P. R. Portje, R. D. Axel.

618 Chemicolloid Laboratories Inc., Garden City Park, N. Y. Charlotte colloid mill.

1220 Chemineer, Inc., Dayton, Ohio. Fluid mixing equip., feature experimental agitator w/ dynamometer, TurboTube agitator working model, portable agitator. R. A. Schaeffer, P.; R. L. Bates VP; E. V. Goodwiller, Ch. Des. Engr.

1070 Chemiquip Co., New York, N. Y. Pressure snubbers, mercury traps.

962 Chemopure Mfg. Corp., Newark, N. J. Industrial fungicides & preservatives featuring "Chemocide" materials, water-soluble salicylanilide and chlor-cresol.

659 Chempump Corp., Philadelphia, Pa. Seal-less centrifugal, canned pumps, for liquids and slurries.

868, 870 Chiksan Co., Brea, Calif. Swivel joints.

1423 Chrysler Corp., Missile Operns., Detroit, Mich.

935 Clark Bros. Co., Div. Dresser Opns, Olean, N. Y. Engines & compressors.

1387, 1389 C C Pump Mfg. Div., Clark-Cooper Co., Palmyra, N. J. Metering pumps, feature straight-plunger and diaphragm types. R. A. Taylor, gen. mgr.; R. H. Sawyer, F. M. Willis, M. Care.

1276, 1278, 1280, 1309, 1311, 1313 Clark Equip. Co., Constr, Machy. Div., Benton Harbor, Mich. Materials handling automotive equip.

1432 Clary Corp., San Gabriel, Calif. Computers.

993, 995 Cleveland Vibrator Co., Cleveland, Ohio. Air-operated bin vibrator.

Valve with electro-hydraulic operator: The Okadee Company, Booth 1386.

158 Cleveland Worm & Gear Co., Cleveland, Ohio. Horizontal & vertical speed reducer units, precision mechanical variable speed drive. L. O. Witzenburg, VP; R. E. Dittoe, sls.

320 Coleman Instruments Inc., Maywood, Ill. Electrometric scientific appar.

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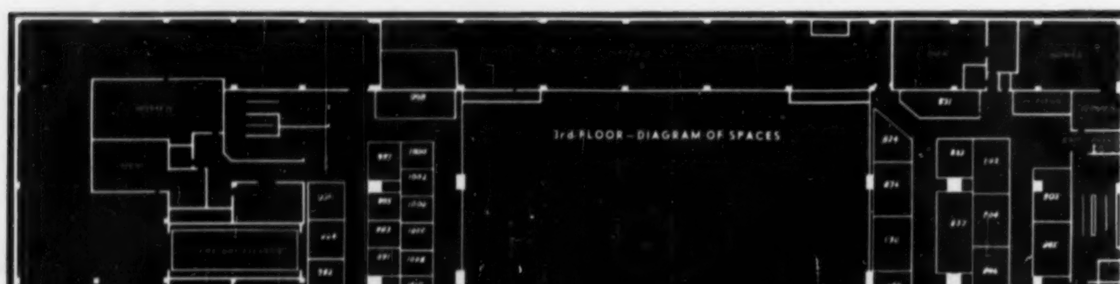

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1262, 1264 Colonial Plastics Mfg. Co., The, Indus. Div., Cleveland, Ohio. Fabricated plastic prods., feature PVC prods. L. C. Jones, P; W. Hatfield, C. R. Owen.

50 Colton Co., The Arthur, Detroit, Mich. High speed mixing, filling, coating, drying, granulating, and tabletting equip. K. B. Hollidge, VP; W. A. Doepel, sls; L. P. Gadja.

1044 Columbia-National Corp., Cambridge, Mass. Zirconium sponge, ingot & mill prods.

646 Combustion Engrg., Inc., Raymond Div., Chicago, Ill. Pulverizing, air separating & flash drying equips., feature Raymond vert. mill, & flash drying syst. A. R. Jenny, sls mgr.; R. D. Nickerson, & others.

223 Commercial Filters Corp., Melrose, Mass. Ful-flo filters & honeycomb filter tubes, synthetic fibers for corrosive fluids. R. L. Fielding, P; C. I. Wallace, J. R. Chisholm, A. E. Poole.

111 Conneaut Rubber & Plastics Corp., Conneaut, Ohio. (See U. S. Stoneware.)

899, 901, 903 Continental Can Co., Inc., Robt. Gair Paper Prods. Group Fibre Drum & Corrugated Box Div. New York, N. Y. Fiber drums and corrugated boxes.

1067 Continental Copper & Steel, Alloy Fabricators Div., Perth Amboy, N. J. Rotary vacuum dryer, alkyd resin installation. F. H. Golden, sls mgr; R. E. Nevett, A. Grodner, A. Cooper.

1236 Continental Emsco Co., Los Angeles, Calif. Swivel joints for use from vac. to 15,000 psi and sub-zero to 750°. W. T. Powell, VP; W. J. Alexander, H. J. Schlarb & others.

1050 Continental Mfg. Co., Cincinnati, Ohio. "Tufline" ss plug valves for vac. to 230 psi operation; feature 3-way valve. C. L. Reed Jr., P; F. A. Godley Jr., D. Sinkler.

103 Cooper Alloy Corp., Hillside, N. J. Valves & fittings for extremely low & high temp. operation, ss fittings suitable for nuclear work.

1060 Corley Co., Inc., The, Plainville, Conn. Horizontal, vertical, 45°-mtd & submerged centrifugal packless pumps. R. N. Corley, P; R. Harland, F. Delaney.

1110 Cornell Mach. Co., The, New York, N. Y. Versator for small flow rates, Micro-Sonic Separator. W. E. Buckley, P; J. M. Gulick, F. H. Vogel.

134 Corning Glass Wks., Corning, N. Y. Glass ware and piping for lab and indust. use, feature borosilicate glass valve with fiber glass-resin armor. O. M. Loytty, R. D. Sweigart, & others.

422 Crane Co., Chicago, Ill. Corros. resist. alloy valves, feature valves of metals and plastic, special valves for AEC use. J. E. Bradbury, mgr., F. Wagner, & P. Basner.

908 Crane Packing Co., Morton Grove, Ill. Mechanical seals, metallic, plastic and fabric packings.

1045 Crawford Fitting Co., Cleveland, Ohio.

1000 Crawford & Russell, Inc., Stamford, Conn. Polymer plant engineering.

1344, 1346 Croll-Reynolds Co., Inc., Westfield, N. J. Refrigerating systems, vac. pumps, jet ejectors, feature "Convactor" recovery unit. D. H. Jackson, gen. mgr; P. E. Reynolds, P; J. T. Reynolds & others.

1344, 1346 Croll-Reynolds Engrg. Co. Inc., New York, N. Y. Heat exchangers, expansion joints, featuring ClaRite filtration equip. R. S. Croll, P; L. O'Hanlon, W. Korb.

1380, 1382 Cuno Engrg. Corp., Meriden, Conn. Pressure filters, feature Auto-Klean metal edge type, Flo-Klean wire-wound type, Micro-Klean wool/cellulose cartridge type, and Por-Klean porous ss type. R. Scott, C. Winslow.

818 Davenport Mach. & Fdy. Co., Davenport, Iowa. Rotary dryers, rotary press dehydrating equipment. L. W. Follett, VP; C. Hagen, W. Kemp, H. Carlton.

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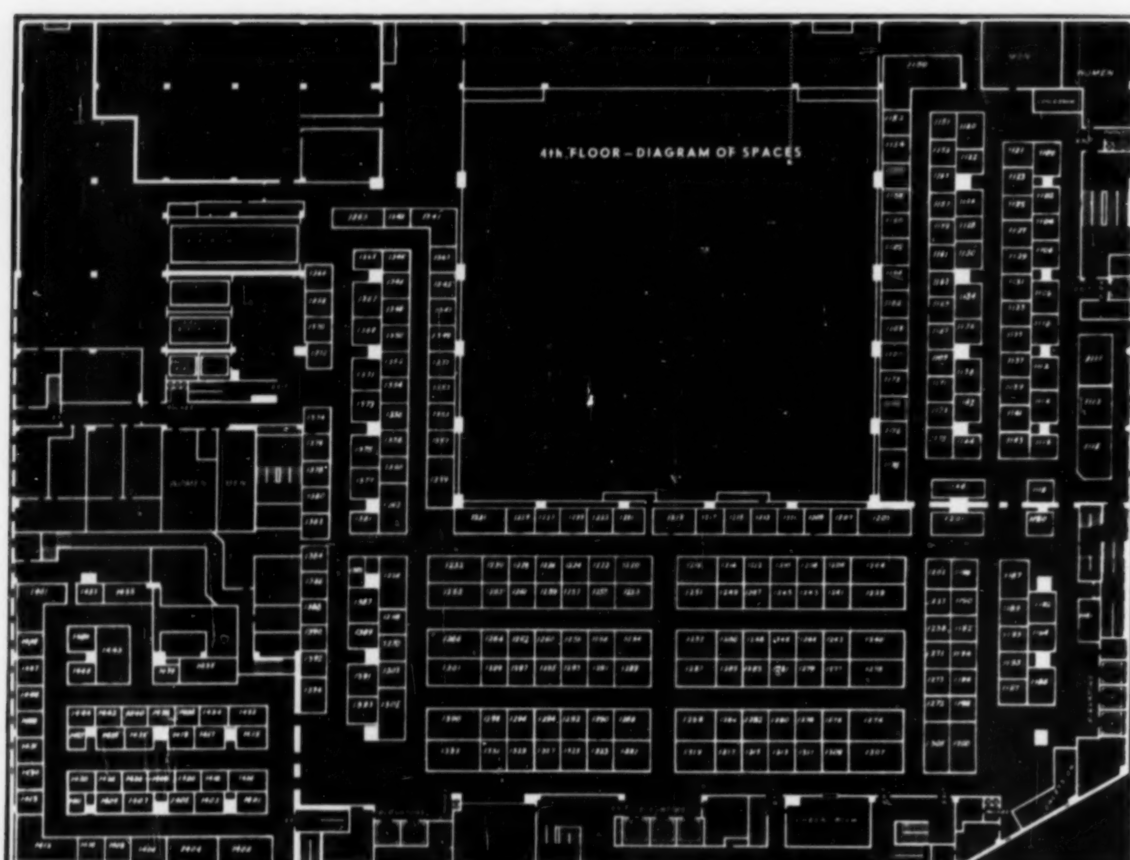

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13 Day Co., The, Minneapolis, Minn. Dust filtration units, feature combination cyclone and filter. R. E. Gorgan, VP; A. E. Swanson, E. W. Anderson.

121, 122 Day Div., The J. H., of Cinn. Automatic Mach. Co., Cincinnati, Ohio. Kneading & blending equipment, feature double-dispersion and Pony twin-blade mixers. J. L. Diltz sls mgr, I. Wershay, C. McBride, R. Mader, R. N. Harris.

184 Dean Thermo-Panel Coil Div. Dean Prods. Inc., Brooklyn, N. Y. Valve warmer. M. Raskin,P; R. Raskin, M. W. Erlich.

1211, 1213 DeLaval Separator Co., Poughkeepsie, N. Y. Centrifuges, hermetic separator, continuous desludger, plate heat exchanger. G. F. Wheelwright Jr., W. C. Porch, F. E. Lawatsch, F. J. Lawry.

1187, 1189, 1193 Delaware Barrel & Drum Co., Inc., Wilmington, Del. Molded polyethylene tanks, drums, fittings and faucets, feature Single-Trip molded PE drum. J. S. Heisler, VP; J. Barber, A. Starr, & others.

1076 Derrick Mfg. Co., Buffalo, N. Y. Hi-freq. vibrating screens, conveyors, shakers. Feature hi-speed screening machine. H. W. Derrick, R. G. Derrick, D. Redmond.

1168, 1170 Despatch Oven Co., Minneapolis, Minn. Furnaces, ovens, dryers & sterilizers, etc.

1201 Dexter & Sons Inc., Windsor Locks, Conn. Special weight fibers and papers, filters.

907 De Zurik Corp., Sartell, Minn. Valve & machy, mfrs., feature non-lubricated eccentric valve, knife gate valve. D. DeZurik Jr., R. Lombard, H. Lounsbery.

204 Dicalite Dept. Gt. Lakes Carbon Corp., Los Angeles, Calif. Mineral filters, diatomaceous silica filteraids, etc.

1295, 1297 Dore' Co., J. L., Houston, Texas. Teflon-lined pipe, teflon gaskets & tubing. J. L. Dore', P; J. S. Bawcom, VP.

531 Dorr-Oliver Inc., Stamford, Conn. Proc. ind. equip., feature DSM Screen size seperator, Mercone screening centrifuge. T. B. Ford, E. L. Oliver, D. C. Reybold, VP's.

1429 Dow Chem. Co., The, Magnesium Dept., Midland, Mich. In conj. w/ The Saran Lined Pipe Co., feature complete line saran-lined transmission equip. for corrosive fluids. J. A. Kloustin, sls mgr; J. W. Reed, gen. mgr; E. E. Chamberlin, prod mgr.

Saran-lined pump: Dow Chemical Company. Booth 1429.

631 Downingtown Iron Wks, Inc., Downingtown, Pa. Div. of Pressed Steel Tank Co. Steel tanks, heat exchangers, steel plate constr.

987, 989 Dracco Corp. Cleveland, Ohio Airstream conveyors, dust filters & collectors, feature filter for hot, corrosive dusts & fumes. G. A. Giesler,P; H. W. Gaeckle, G. Schnieder, & others.

1150 Dravo Corp., Neville Is., Pittsburgh, Pa. Process equip. feature agitated, rotary, conical dryer, vibrating screens & conveyors. O. F. Redd, R. J. Allison, G. W. Plohr.

1033 Ducon Co., The, Mineola, N. Y. Dust control, package type centrifugal wet dust collector. R. R. Leech, K. A. Weits.

1289, 1291, 1293 DuPont Co., Polychemicals Div., Wilmington, Del. Applications of Teflon fluorocarbon resins in chem. ind. W. A. Franta, R. A. Kellar, R. B. Fehr Jr.

1245, 1247, 1249 Duralab Equip. Corp., Brooklyn, N. Y. Design & mfg. lab furniture, feature hoods, sinks and base units. N. Ingarra, P; D. Kayne, L. P. Liano, R. E. Massa.

1229 Durametallic Corp., Kalamazoo, Mich. Mechanical seals, metallic packings, oil pressure systems, feature "Circoilator" automatic oil pressure pump.

520, 532 Duriron Co. Inc., The, Dayton, Ohio. Acid-resist valves, pumps, pipe & fittings.

1299, 1301 Dustex Corp., Buffalo, N. Y. Dust Collecting systems.

1049 Du Verre, Inc., Arcade, N. Y. Resin-bonded fiber glass prods. T. F. Killeen, sls mgr; H. Hasbrouck, ch. engr.

1275 Eastern Industries Inc., Hamden, Conn. Centrifugal pumps and mixing equip. for corrosive liquids. R. S. Hadley, K. D. Rose, J. Short, W. Olson.

822 Eastern Stainless Steel Corp., Baltimore, Md. SS sheets & plates. R. C. Cunningham, J. W. Stotlemyer, N. L. Ellis & E. Seth.

1046, 1048 Eastman Kodak Co., Rochester, N. Y. Photo film paper, appar supplies & chemicals.

1120 Eaton-Dikeman Co., The, Mt. Holly Springs, Pa. Filter papers for indus. use in filter presses, and lab filter papers. T. H. Logan Jr, K. Buff, F. T. Yeingst, C. E. Avery.

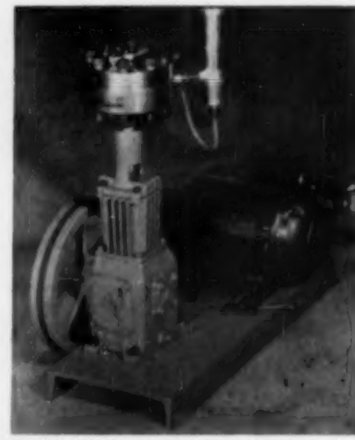
981 Eclipse Fuel Engrg. Co., Rockford, Ill. Package steam generators.

978 Eco Engrg. Co., Newark, N. J. Rotary & centrifugal pumps, portable pumping unit, "Minilab" rotary pump for lab or pilot plant, ss chemical faucet w/teflon seal rings. J. Eisenberg, E. Anderson.

80 Eimco Corp., The, Salt Lake City, Utah. Agitators, ball rod & tube mills, vac. drum & disc filters.

373, 375 Electric Hotpack Co. Inc., Phila., Pa. Design & mfg controlled temp. equip. feature Controlled Temp environmental walk-in rooms, and recirculating Tray Dryer. A. S. Mann, exec VP and staff.

1152 Electro Dynamic Div., Gen Dynamics Corp., Bayonne, N. J. Electric motors & generators.



Small laboratory compressor: Pressure Products Industries, Inc., Booth 1180.

1129 Electroweld Mfg. Corp., Erie, Pa. Steel, stone work.

190, 192, 196, 225 Englehard Inc., Charles, East Newark, N. J. Indus. instr. pyrometers, thermocouples.

190, 192, 196, 225 Englehard Industries, Newark, N. J. (See Chas. Engelhard Inc.)

645 Entoleter Div., Safety Indust. Inc., New Haven, Conn. Centrifugal machines and filter dust collectors, feature CentriMil size reduction, impact milling machs for high intensity mixing and for extremely high impact vel. R. J. Hoskins, G. B. Stearns, R. J. Fitzgerald, P. Whetstone.

909, 911 Eriez Mfg. Co., Erie, Pa. Perm. magnetic equip for process indust, feature electro-permanent magnetic vibratory feeders. R. F. Merwin, P; R. A. Roosevelt, N. Hirt, F. Anderson, & others.

623 Ertel Engrg. Corp., Kingston, N. Y. (See Metal Glass Prods. Co.) Liquid handling equip filter presses, disk filters, plastic filters, etc. Feature ss totally-enclosed disk filter. F. J. K. Ertel,P; J. F. Schomer, G. P. Vogel, W. W. Bryant.

971 Ethylene Chem. Corp., Summit, N. J. Plastic tubing.

1371, 1373 Exact Weight Scale Co., The, Columbus, Ohio. Predetermined weight scale.

1164, 1166 Fairbanks, Morse & Co., Chicago, Ill. Electronic batching, weighing, conveying & loading. J. S. Peterson, C. G. Gehringer, J. T. Letkey.

1343 Falcon Alarm Co., Summit, N. J.

1174, 1176 Falcon Mfg. Div., First Machry Corp., Brooklyn, N. Y. Reaction vessels, agitators, cutters, mills, filter presses, heat exchangers, feature ribbon blender.

131 Falls Industries Inc., Solon, Ohio. Impervious graphite piping system, pumps incorporating graphite construction, Impervite tube type absorption towers.

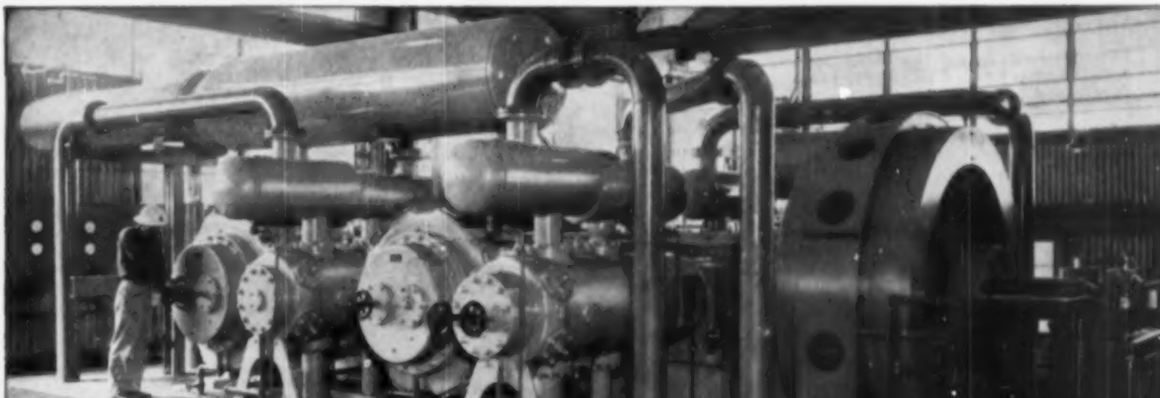
617 Fansteel Metallurgical Corp., Chicago, Ill. Tantalum processing equip. Featuring tantalum electric immersion heaters. L. Scribner, C. A. Hampel, J. V. DiMasi, A. L. Percy.

158 Farval Corp, The, Cleveland, Ohio. Centralized lubrication systems, spray lubrication systems on gears & slide surfaces. L. O. Witzenburg, VP; E. J. Gesdorf, H. H. Platek.

(Continued on page 102)

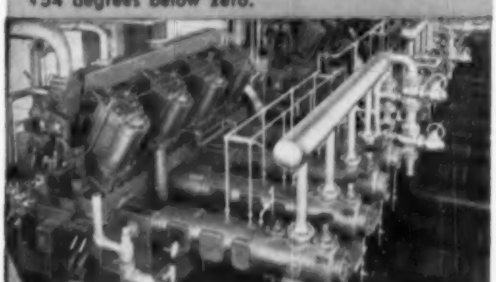
what assures a

GOOD COMPRESSOR for PROCESS WORK?

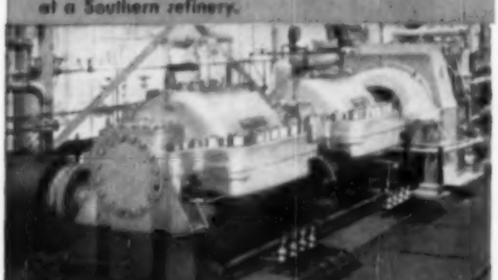


ELECTRIC-DRIVEN horizontal 4000-hp HHE compressor on multiple-gas service, compressing air to 645 psi, nitrogen to 330 psi and natural gas to 440 psi simultaneously in an ammonia plant.

STEAM-DRIVEN compressors with non-lubricated cylinders handling hydrogen chloride gas at -54 degrees below zero.



GAS-ENGINE compressors with non-lubricated compressor cylinders on hydrogen recycling duty at a Southern refinery.



CENTRIFUGAL compressors on ethylene refrigeration; these are tandem units driven by steam turbine.

In process jobs, any interruption of the cycle often means large loss of production, expensive repairs, and introduction of hazardous conditions. In manufacturing compressors for these jobs, there is one ingredient most vital.

That ingredient is knowledge. The compressor manufacturer must know how to predict conditions in the process which might force a shutdown, and must know how to meet those conditions with a compressor which will minimize the possibility of a shutdown.

Such knowledge is obtained only through years of actual experience in designing, building and applying compressors for all sorts of processes, for handling all kinds of gases, and for any range of pressures.

Ingersoll-Rand has more of that kind of experience than any other compressor builder. For information on process compressors for pressures up to 35,000 psi, contact your I-R representative or write direct. Ask for your copy of Form 3132A.

Ingersoll-Rand

1-598 11 Broadway, New York 4, N.Y.

COMPRESSORS · GAS & DIESEL ENGINES · PUMPS · AIR & ELECTRIC TOOLS · CONDENSERS · VACUUM EQUIPMENT · ROCK DRILLS

26th EXPOSITION OF CHEMICAL INDUSTRIES

111 Federal Refractories Corp., Mineral City, Ohio. (See U. S. Stoneware.)

1391 Fibercast Corp., The, Sand Springs, Okla. Fibercast tubing & line pipe and fittings. J. Hutchinson, H. D. Boggs, E. D. Edminston.

1158 Filterite Corp., Timonium Md., Filter vessels, broad range of cartridge filters for particle selection 100 down to 1 micron.

456 Filtration Engrs. Inc., Newark, N. J. Design & mfr all types continuous filtration equip, featuring pilot plant units used to design large commercial units. H. M. Small, sls mgr; L. A. Jauhola & J. M. Stauffer.

854, 856 Filtros, Inc., E. Rochester, N. Y. Porous ceramic prods.

1450 Finn Aeronautical Div. T. R. Finn & Co., Hawthorne, N. J. Vibration absorption & isolation for machy.

872 Fischbein Co., Dave, Minneapolis, Minn. Portable bag closer.

496, 545 Fischer & Porter Co., Hatboro, Pa. Process instrumentation, chlorination equip, data reduction & automation, feature magnetic flowmeter, redox-potential cell, electronic tank level gauge & many other items. K. Fischer, P; R. Rice, R. Shapcott, J. Haskett & W. Conway.

386 Fisher Scientific Co., Pittsburgh, Pa. Lab appar & reagents, feature controlled potential electro-analyzer, "Partitioner" for petrochem analysis. C. C. Lang, P. Stoddard, R. Schlick, F. Brewer, G. Lord.

1095 Fitzpatco Corp. Div. of W. J. Fitzpatrick Co., Chicago, Ill.

49 Fitzpatrick Co., The W. J., Chicago, Ill. Mills and pulverizing machy.

459 Fletcher Works Inc., Phila., Pa. Chemical centrifugals, featuring full automation. E. T. Taws, P; R. Scholes, H. B. Allison.

1343 Flow Actuated Control Co., Englewood, N. J.

997 Fluid Energy Proc & Equip Co., Phila., Pa. Fluid energy jet grinding mills, fine particle Cyclone dust collector. N. N. Stephanoff, P; F. E. Albus, J. P. McKenna.

1036 Fluor Prods. Co., Whittier, Calif. Cooling towers, plastic packing, air classifying, pneumatic conveying, dust & fume collection systems. J. P. Wiseman, P; G. H. Dieter & J. W. Elizardi, and others.

14 Foote Bros. Gear & Machine Corp., Chicago, Ill. Indust gears, centrifugal clutches.

947 Foster Engrg Co., Union, N. J. Automatic valves, control valves, governors, etc.

519 Foxboro Co., Foxboro, Mass. Process control & recording insts featuring multi-record dynalog recorder, diaphragm type flowmeter, magnetic flowmeter, pneumatic integrator.

446 Freezing Equip. Sales Inc., York, Pa.

1258, 1260 Frick Co., Waynesboro, Pa. Air condtg, ice making & refrig machy.

446 Fuller Co., Catasauqua, Pa. Compressors, industrial fans, blowers, high temp. wheel for indust fans. G. C. Kaesemeyer, G. K. Engelhart, G. R. Wachter, R. P. Howell, L. J. Luckenbach & many others.

1054 Galigher Co., The, Salt Lake City, Utah. Mining machy.

415 Garlock Packing Co., Palmyra, N. Y. Mechanical packings and gasket matls featuring teflon, Kel-F and silicone plastics. J. B. Sewell, A. E. Munch, R. Lyons & F. Wilders.

1121, 1123, 1125 Gaylord Container Corp. Div. of Crown Zellerbach Corp., St. Louis, Mo. Corrugated shipping containers for up to 1 ton of chemicals. W. H. Jennings, G. G. Hertslet, W. J. McDonald and others.

916 Geigy Industrial Chemicals Div. of Geigy Chem Corp., Ardsley, N. Y. Surface-active agents, sequestering agents, chelates, fluorescents, U-Violet absorbers, corrosion inhibitors.

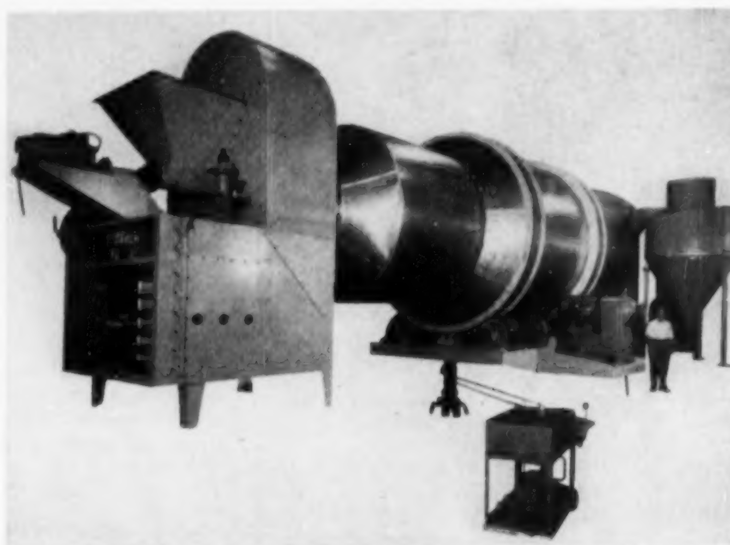
967 General Plastics Corp., Paterson, N. J. Teflon & Kel-F coatings for proc equip, impreg glass cloth, feature nylon aqueous dispersion.

219 Gifford-Wood Co., Hudson, N. Y. Storage, elevating & conveying machy.

94 Girdler Co., The, Div of Nat'l Cylinder Gas Co., Tube Turns Dept., Louisville, Ky. Seamless welded fittings and flanges in several kinds of metals. W. P. Curley mgr, J. C. Richburg, D. E. McNellis.

94 Girdler Co., The, Div of Nat'l Cylinder Gas Co., Votator Div., Louisville, Ky. Cont proc appar, heat transfer and aux equip. L. D. Roy Jr., sls mgr; H. E. Huber, R. L. Smith and others.

94 Girdler Co. The, Div. of Nat'l Cylinder Gas Co., Catalyst Dept., Louisville, Ky. Custom-designed catalysts for many proc indus oper. P. B. Boyd Jr., O. R. Matzner, E. R. Englert and others.



Dehydro-Mat drying system: Edw. Renneburg & Sons Company, Booth 1078.

1343 Gems Co., Newington, Conn. Liquid level & flow controls.

193 General Alloys Co., Boston, Mass. Heat resist stainless & abrasion resist alloy castings.

131 General Ceramics Corp., Keasbey, N. J. Stoneware, alumina, quartz, ceramics and corro-resist plastic matls for use in proc equip. C. E. Eisenmann, C. A. Brooks, R. L. Karesh.

967 General Dispersions Inc., Paterson, N. J.

1152 General Dynamics Corp. Electro Dynamic Div., Bayonne, N. J. (See Electro Dynamics.)

482 General Electric, Rocket Engine Sect., Cincinnati, Ohio. First stage rocket engine of Vanguard, liquid rocket engine. B. Hamlin, mgr; R. J. Hughes, H. M. Weber, D. E. Wright.

310 General Laboratory Supply Co., Paterson N. J. Chemicals & appar for indust & labs; featuring Thermoregulator accur to 1/100 degree, electric lab stirrer. J. Vennik, A. Samuelson.

94 Girdler Co., The, Div of Nat'l Cylinder Gas Co., Tube Turns Plastics Inc., Louisville, Ky. Fittings, flanges, and valves of unplasticized PVC, PVC instrumentation fittings. C. B. McLaughlin Exec VP; J. W. Hendry, VP; E. Erich, J. S. McCulloch, J. H. Hunt.

60 Glengarry Inc., Bayshore, N. Y. Can fillers, scales, etc.

890, 892 Globe Co., The, Chicago, Ill. Metal gratings and cable trays. H. M. Donnelley, L. Friestedt.

1204 Goulds Pumps Inc., Seneca Falls, N. Y. Corros-resist centrifugal pumps featuring Goulds-Pfaudler glassed pump. S. A. Bunis, P. J. Olmstead, P. Lahr, R. Fornesi.

1246 Gow-Mac Instrument Co., Madison, N. J. Gas analysis, indicators & controllers.

204 Great Lakes Carbon Corp., New York, N. Y. Dicalite filter aids, Perlite aggregate expanders, special types of carbon and graphite electrodes. J. E. Moran, asst gen mgr; P. W. Leppla, E. J. Manion & others.

(Continued on page 104)

26th EXPOSITION OF CHEMICAL INDUSTRIES

216 Great Western Mfg. Co., Leavenworth, Kansas. Sifting, screening & flour mill and grain elevator machy.

41 Greif Bros Cooperage Corp. Lindenhurst, L. I.

566 Grinnell Co. Inc., Providence, R. I. Fire protection, systems, automatic sprinklers, etc.

1024, 1026 Gump Co., B. F., Chicago, Ill. Proc equip; featuring Sifter box, Draver feeder, and Ideal roller mill. M. F. Frankel, VP; E. J. Miler, D. Kerwin, R. Warner, G. F. Allen.

1268, 1270 Hamer Valves Inc., Long Beach, Calif. Mfrs. valves, pipe, fittings.

1341 Hamilton Kettles Div Brighton Corp. Cincinnati, Ohio.

359 Hamilton Mfg. Co., Two Rivers, Wisc. Steel lab furniture, glassware drying equip. titration bench assemblies. A. R. Salveson, sls mgr; C. Colligan & G. Nagler.

190, 192, 196, 225 Hanovia Chem & Mfg Co., Newark, N. J. Quartz chem lab appar, U-V lamps.

1345 Hapman Conveyors, Inc. Div Hapman Dutton Co., Kalamazoo, Mich. Tubular conveyors, elevators, conveyor access.

1241, 1243 Harbison-Walker Refractories Co., Pitts., Pa. Fire clay, alumina, silica, etc. refractories.

582 Hardinge Co. Inc., York, Pa. Indus proc machy; featuring: Disc Roll Mill, Gyrotor air classifier, Tricone mill, automatic backwash sand filter, Aoturaise thickener, rotary dryer.

994 Harman Assoc., F. Ward, Halesite, L. I., N. Y. Scale model parts & access.

1092 Haring Equip. Corp., Newark, N. J. Automatic tube filling machs for indust & small plant use. J. Boyar, serv mgr.

1032, 1034 Harper Co., H. M., Morton Grove, Ill. Non-corrosive bolts, nuts & extruded shapes. J. Turnbull, K. Mulroy.

369 Hart Moisture Meters (Raymond S. Hart Inc.) Babylon, L. I.

546 Haveg Ind., Inc., Wilmington, Del. Proc indus equip of corros-resist plastics. J. H. Lux, P; J. W. Carrow, gen sls mgr, J. B. Mackenzie.

460 Haynes Stellite Co. Div of UCC, New York, N. Y. Corrosion & heat resistant alloys. C. G. Chisholm & E. W. Connolly, sls mgrs.

1343 Healy-Ruff Co., St. Paul, Minn.

1305 Heil Process Equip Corp., Cleveland, Ohio. Chem resistant equip & matls; featuring plastic vent fans, fume scrubbers, portable storage tanks. C. E. Heil, P; F. W. Arndt, ch. engr.

1074 Heinecke Instruments, Hollywood, Fla. Stainless pumps, lab glassware washers. K. J. Heinecke, P; J. R. Heinecke, & W. Burkhart.

213 Hercules Filter Corp., Hawthorne, N. J. Self-cleaning Roto-Jet, leaf filter, filter matls, suction leaf filter for corrosive liquids. R. Zust.

813 Hetherington & Berner Inc., Indianapolis, Ind. Dryers, Mixers, jacketed fittings.

15 Heyl & Patterson Inc., Pitts., Pa. Design fabricate large size crushing and conveying machy. Liquid cyclones.

1272 High Pressure Equip Co., Erie, Pa. Hi-press valves, fittings, tubings reactors, autoclaves.

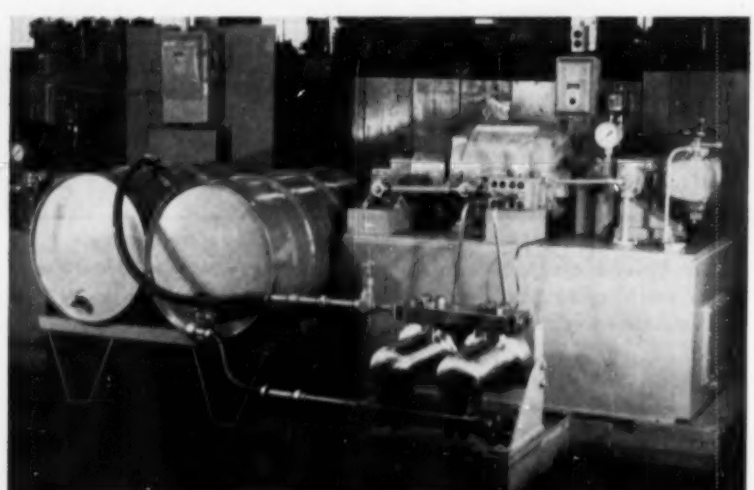
1171, 1173, 1175 Hills-McKenna Co., Chicago, Ill. Proportioning pumps, diaphragm valves, gages, alloy castings.

1178 Hockmeyer & Co., H., Bronx, N. Y. Mfr mixing machy, conveyors and indus equip, feature horizontal paste mixer, pony paste mixer, DiscPerser unit. H. Hockmeyer, S. R. Klein.

201 Hoke Inc., Englewood, N. J. Valves, regulators, cylinders.

977 Hormann & Co. Inc., F. R., Newark, N. J. Liquid clarification and polishing filters also lab filters. M. Coblens, H. E. Stapowick.

63 Hough Co., The F. G., Libertyville, Ill. Payloader tractor shovels, indust, matl handling equip. G. A. Tamblyn, sls mgr.



Variable volume Hydropulse pump: Scott & Williams, Inc., Booth 1146.

645 Howe Scale Co., The, Rutland, Vt. Batchmaster weight control, Digitweigh weighing system. R. F. Straw, VP.

1200 Hungerford & Terry Inc., Clayton, N. J. Water softeners, filters & zeolites.

1029 I-T-E- Circuit Breaker Co., Phila., Pa. Air-, thermal-, & magnetic type circuit breakers.

888 Illinois Water Treatment Co., Rockford, Ill. Water treating equip.

894-896 Imperial Brass Mfg. Co., Chicago, Ill. Tube fittings, fluid control valves, tube-working access. H. Philippe, P.

635 Indust. Div. Minneapolis-Honeywell Reg. Co., Phila., Pa. Potentiometers, pyrometers, flow meters, etc.

1188, 1190, 1192, 1194, 1196, 1202, 1237, 1238, 1271, 1273 Industrial Filter & Pump Mfg. Co., Chicago, Ill. Pressure filters, demineralizers, heat exchangers, centrifugal pumps, etc.

1217 Industrial Plastic Fabricators Inc., Norwood, Mass. Rigid PVC structural matl, PVC centrifugal blowers, fans, air washers, fabricated & machnd parts. H. Starback, R. Bowker, E. D. Nicolle.

1215 Industrial Prods Engrg Co., L. I. City, N. Y. Racks, skids, conveyors, mixers, dust collectors, etc.

1321 Industrial Steels Inc., Cambridge, Mass. Stainless steel.

1163 Infilco Inc., Tucson, Ariz. Twin-throat venturi tube, Viscomatic lime slaker, Neusol chem feeder, water & indust waste treatment equip. E. G. Kominek, VP sls; A. A. Kalinske, G. E. Hauer.

128 Ingersoll-Rand Co., New York, N. Y. Non-lubricated compressor, direct contact condenser pumps, air-operated tools and hoists.

812 International Engineering Inc., Dayton, Ohio. Portable mixers, agitators, laboratory Muller, turbine impellers; featuring stabilizer baffle. A. P. Weber, M. Shackelford, I. A. Stark.

509 International Nickel Co. Inc., The, New York, N. Y. Nickel and its alloys.

1016 Jabsco Pump Co., Burbank, Calif. Small rotary self-priming pumps with neoprene impeller, models in ss, bronze, cast iron, plastic. M. G. McLean, sls engr.

1362 Jacoby-Tarbox Corp., Yonkers, N. Y. Filter paper & cloths, flow indicators.

1038 Jamesbury Corp., Worcester, Mass. Double seal ball valves in ss, carbon steel, bronze and PVC. J. S. Freeman, sls mgr.

1343 Jarco Services Inc., Tulsa, Okla.

97 Jeffrey Mfg. Co., The, Columbus, Ohio Materials processing and handling equipment.

409 Jenkins Bros., New York, N. Y. Valves.

1182, 1184 Jerguson Gage & Valve Co., Burlington, Mass. Direct reading liquid level gages, featuring magnetic gage for liquid level. R. Stanley, C. Fletcher.

(Continued on page 106)

26th EXPOSITION OF CHEMICAL INDUSTRIES

172, 176 Johns-Manville Sales Corp., New York, N. Y. Celite filter-aids, mineral filters, Micro-cel (synth. calcium silicate). R. H. Cipolla, T. M. Jackson.

1128, 1130 Kaiser Aluminum & Chem Sales Inc., Oakland, Calif.

1425, 1427 Kaupp & Sons, C. B., Maplewood, N. J.

1141, 1143 Kennametal Inc., Latrobe, Pa. Cemented carbide tools, blanks, & wear-resis parts.

398 Kewaunee Mfg. Co., Adrian, Mich. Lab furniture and equip. Sls personnel.

390 Kimble Glass Co. Div Owens-Illinois, Toledo, Ohio. Special lab glassware, featuring "hard" glass appar. E. J. Rhein, J. F. Ryley.

884, 886 Kinney Mfg. Co. Subs of N.Y. Air Brake Co., Boston, Mass. Pumps & vac-tight valves.

1215 Klein Filter & Mfg Co., L. I. City, N. Y. Diatomaceous earth & pulp filters.

1347 Klinger Inc., Richard, Bklyn, N. Y.

175 Knapp Mills Inc., L. I. City, N. Y. Mfr corrosion-resistant lead and lead-lined prods. & equip. for chem. proc. ind.; featuring "atomic" equip. T. Tschudi.

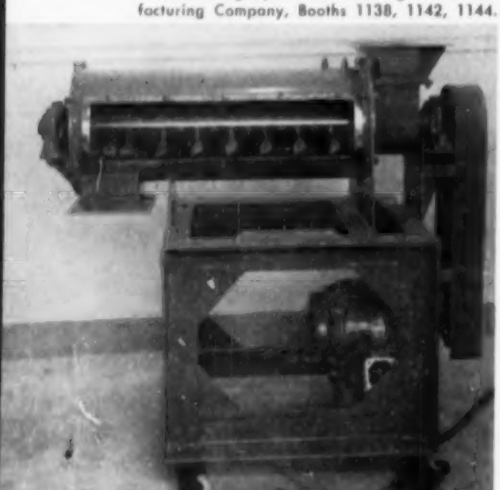
586 Knight, Maurice A., Akron, Ohio. HCl absorber, tower packings, fume washer, of ceramic ware and reinforced plastics. M. A. Knight Jr., P. G. McDermott, R. F. Strigle Jr.

1100 Komline-Sanderson Engrg Corp., Peapack, N. J. Rotary vac and press filters, acid pumps. T. R. Komline, W. H. Sanderson and others.

74 Koven Fabricators Inc., Dover, N. J. Steel & alloy tanks, indust equip.

905 Laboratory Equip Corp., St. Louis, Mo. Lab appar., hi-temp. zirconium ceramics.

Turbulizer-high speed mixer: Strong Scott Manufacturing Company, Booths 1138, 1142, 1144.



309 Laboratory Furniture Co. Inc., Mineola, N. Y. Lab furn & equip.

340 Laboratory Glass & Instr. Corp., New York, N. Y. Flash evaporator, multi-dialyzer, Omni-shaker, and other lab equip. J. Buchler, Mrs. J. Buchler, D. Gelfand.

42 Labour Co. Inc., The, Elkhart, Ind. Type CG packingless pump, self-priming and gravity-feed pumps; featuring new type SZ pump. M. S. Maleson, D. R. Pressey, J. C. Reynolds.

1288, 1290 Ladish Co., Cudahy, Wisc. Weldings, fittings, forged steel.

1292, 1294 Ladish Co., Tri-Color Div., Kenosha, Wisc. Ss fittings, valves, pumps.

922 Lancaster Chem Corp., Carlstadt, N. J. Protective coatings.

696 Lapp Insulator Co. Inc., LeRoy, N. Y. Auto-pneumatic "microflo," "Electromatic" pulsafeeder, and Pulsafeeder diaphragm compressor pumps.

852 Lawrence Pumps Inc., Lawrence, Mass. Centrifugal pumps; featuring Vertical 5-stage liquid oxygen, and horizontal propeller & slurry pumps. V. J. Mill Jr.

816 Lead Industries Assoc., New York, N. Y. Industrial applications of lead, radiation shields, lead compounds in infra-red, dry cells, etc. R. L. Zeigfeld, D. M. Borcina, E. J. Mullarkey.

70 Lead Lined Iron Pipe Co., Wakefield, Mass. Lined pipe, fittings, valves, coils.

20 Lebanon Steel Fdry., Lebanon, Pa. Carbon low-alloy & ss castings; featuring Ceramicast. J. H. Boyd, A. W. Blecker, E. H. Platz Jr.

1205 Lehman Co Inc., Lyndhurst, N. J. Proc machy.

1227 Lennard Co Inc., Bklyn, N. Y.

1333 Leslie Co., Lyndhurst, N. J. Regulators, controllers, strainers.

460 Linde Co, Div of UCC, New York, N. Y. Oxy-acetylene chemicals.

165 Link-Belt Co., Chicago, Ill. Roto-Louvre Dryer, Helicoid screw conveyor, bulk matls handling system, vibrating screen and self-aligning bearings.

883 Logan Emergency Showers Inc., Glendale, Calif. Decontaminating & portable emergency showers, emergency eye, nose & mouth wash fountains. H. Logan, J. Johnson, R. Church.

836, 842 Louisville Drying Machy Unit, Gen. American Transportation Corp., New York, N. Y. Agitation equip, cont. extractor, fluidized-bed dryer, airslide car, Kanigen-coated tank car.

876 Lukens Steel Co., Coatesville, Pa. Corros-resist clad steel, Hastelloy-clad heads, clad-steel welding. H. T. Barr, W. H. Funk.

835 Luzerne Rubber Co., Trenton, N. J. Hard rubber prods, rigid PVC custom-molded parts. E. P. Case.

910, 912 Magnetrol Inc., Chicago. Ill. Magnetrols with anti-vibration mercury switches. R. J. Haupt.

1135 Mallory-Sharon Titanium Corp., Niles Ohio. Titanium & its alloys in structural shapes.

1115 Mannesmann-Easton Plastic Prods Co. Inc., Easton, Pa. Plastic pipe & tubing.

Grid-supported Yorkmesh Demister: Otto H. York Company, Booth 69.

51 Manton-Gaulin Mfg Co. Inc., Everett, Mass. Indust. homogenizers, colloid mills, hi-press. ss pumps, featuring rotary positive displacement pump.

1053, 1066 Marlo Coil Co., St. Louis, Mo. stainless steel heat transfer equip, air washers, cooling towers, dehumidifiers.

1419 Marman Div Aeroquip Corp., West Los Angeles, Calif. Clamps, straps & couplings.

1251 March Stencil Mach Co., Belleville, Ill. Stencil cutting machs, tape dispenser, stencil & marking inks.

1420, 1422 Martin Co., The, Baltimore, Md.

1118 Martin Engrg Co., Neponset, Ill. Controlled air and electric vibration, inducers. W. Dougherty, E. F. Peterson.

991 Martinson Mach Co., Kalamazoo, Mich.

10 Master Electric Co. Div of Reliance Electric & Engrg Co., Dayton, Ohio. Elect. motors, generators, speed reducers.

1341-1343 McIntosh Equip. Corp., New York, N. Y. Pumps, proc equip, & controls. A. J. McIntosh, A. N. Karp, F. L. Goetz.

1094 Metals & Controls Corp., Gen. Plate Div., Attleboro, Mass. Temp control devices.

623 Metal Glass Prods. Corp., Kingston, N. Y. Single shell and dimpled jacketed tanks. W. B. Goodstein, H. W. Winkler, T. J. Potter.

944 Metal Hydrides Inc., Beverly, Mass. Powdered metal alloys.

1020 Metal Textile Corp., Roselle, N. J. Wire mesh filters, entrainment separators, Tray-seal asbestos-monel gasketing. P. P. Ushkaritys, S. C. Reynolds.

336 Metalab Equip Co, Div Norbute Corp., Hicksville, L. I.

339 Mettler Inst. Corp., Hightstown, N. J. Multi-purpose analytical balances for chem labs & plant control. F. C. Tobler, D. Jones.

942 Michigan Chemical Corp., St. Louis, Mo. Brine chemicals & rare earths. C. H. Pfrommer, W. P. McDonnell.

1091 Michigan Wheel Co., Grand Rapids, Mich. Indust. propellers.

1012, 1014 Micro Metallic Corp., Glen Cove, N. Y. Porous ss indust & lab filters, gas spargers, catalyst filters.

1010 Miller & Son, Franklin P., E. Orange, N. J. Size reduction equip. crushers, roller mills, chippers. H. Galanty.

610 Milton Roy Co., Phila., Pa. Controlled volume pumps and chemical feed systems. W. T. Griffiths, J. Procopi, E. W. Anders.

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26th EXPOSITION OF CHEMICAL INDUSTRIES

81 Mine Safety Appliances Co., Pittsburgh, Pa. Personal protective devices. H. D. Edwards, V. J. Elliott, Engrs.

635 Minneapolis-Honeywell Reg. Co., Phila., Pa. Bellows flow-meter, Digital potentiometer, Pulse-duration telemetering system, continuous integrator. F. Kaiser, D. W. Fryback, W. Matlack.

927, 931 Minnesota Mining & Mfg., St. Paul, Minn. Adhesives, chemicals, coated abrasives.

1159 Mirenda Corp., White Plains, N. Y. Rigid PVC valves, fittings and pumps. A. F. Mirenda, J. Gervasi.

1037 Misco Fabricators, Marysville, Mich. Designers, fabricators of heat-resist alloy and ss process equip. featuring Uniflux fractionating trays. G. S. Thompson, L. Griffore, D. B. Cartwright.

817 Mission Mfg. Co., Houston, Tex. Centrifugal pumps of corros reist alloys & plastics, rubber-lined centr. pump and plug valve. C. J. McGee, C. O. Bell, M. C. King.

204 Missouri Coke & Chem Div Gt. Lakes Carbon Corp., St. Louis, Mo.

146 Mixing Equipment Co., Inc., Rochester, N. Y. Fluid mixing machy ranging from lab models to 500 hp indust sizes, featuring "Lightnin" mechanical seal.

881 Monarch Mfg Wks Inc., Phila., Pa. Spray nozzles, air washers, valves, strainers.

930, 932, 934, 961 Montecatini Soc. Gen., Milan, Italy. American Rep.: Chemore Corp., New York, N. Y.

814 Morehouse-Cowles Inc., Los Angeles, Calif. Morehouse mills, Cowles dissolvers. G. E. Missbach, H. F. Purcell, H. F. Meyer Jr.

191 Multi Metal Wire Cloth Co. Inc., New York, N. Y. Rim-lok filter leaf, Micromesh metallic filter cloth, Mykro-pore metallic filter medium.

16 Mundet Cork Corp., N. Bergen, N. J. Cork prods, pipe covering.

1172 Namco Machinery Inc., Bklyn, N. Y. Designers and builders of lab and indust glassware washing & drying machy. M. E. Cole, R. C. Jackson, S. Breier.

238 Nash Engrg Co., The, So. Norwalk, Conn. Compressors, vac return line.

1106 Nalge Co. Inc., The, Rochester, N. Y. Chem & biol lab appar.

460 National Carbon Co. Div UCC., New York, N. Y. Karbate impervious graphite shell & tube heat exchangers, pumps, entrainment separators, valves, pipes and fittings. J. F. Revilock, W. W. Palmquist.

675 National Dust Collector Corp., Chicago, Ill. Dust & fume scrubber, nat'l Hydro-filter. E. B. Henby, J. VanFleet, E. Smith.

675 National Engrg Co., Chicago, Ill. "Elevayor" elevator-aerator, Simpson Mix-muller mixer, Porto-muller.

1113 National Filter Media Corp., The, New Haven, Conn. Liquid filtration cloth.

234 National Lead Co., Titanium Alloy Mfg Div, New York, N. Y. Paint & paint matls, lead & lead alloy prods.

1070 National Instrument Co., Baltimore, Md. Bottle filling machy.

917 National Rosin Oil Prods. Co., Savannah, Ga. Rosin oils & pitches, Galex pellets of non-oxidizing rosin.

917 National Tube Div US Steel Corp., Pitts., Pa.

204 Nerofil Dept, Gt. Lakes Carbon Corp., Chicago, Ill.

183 Newark Wire Cloth Co., Newark, N. J. Industrial grades wire cloth (incl. filter cloth), testing sieves and sieve shaker. G. R. Merrell, J. L. Campbell, W. E. Green.

324 New Brunswick Scientific Co., New Brunswick, N. J. Rotary & reciprocating shakers, fermentation equip precision instruments and lab appar. D & S Freedman, J. Lazarus, J. Postman.

79 New England Tank & Tower Co., Everett, Mass. Flange mounted drive, pipeline mixer, portable and flange mounted agitator. J. Lennon, J. Eisner, E. Page.

884, 886 N. Y. Air Brake Co., The, New York, N. Y. Matls handling equip.

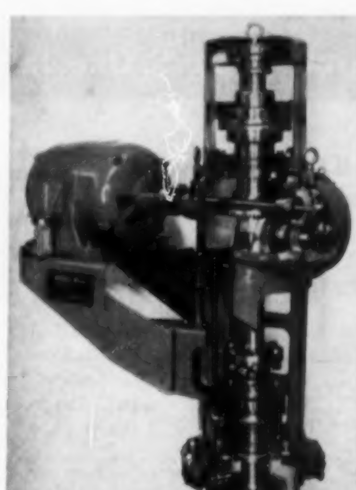
1022 N. Y. Lab Supply Co., New York, N. Y. Lab appar.

655 Niagara Blower Co., New York, N. Y. "Aero" vapor condenser, after cooler, heat exchanger, liquid cooler, spray cooler.

556 Niagara Filter Div Amer Mach & Metals Inc., E. Moline, Ill. Tolhurst centrifuges, Niagara vertical, horizontal tank & horizontal plate type filters. Filtration vacuum, precoat & rotary type filters.

1051 Nichols Engrg Co., Chicago, Ill. Tank car loading and unloading platforms. S. H. Nichols, B. F. Goldman.

624 Nichols Engrg & Research Corp., New York, N. Y. Engineers, consultants, designers of incinerators, roasters, dryers, calciners; featuring powder atomizer. H. B. Nielsen.



Cutaway model of Lightnin' mixer with mechanical seal: Mixing Equipment Company, Booth 146.

68 Niles Steel Prods Div Republic Steel Corp., Niles, Ohio.

443 Norcross Corp., Newton, Mass. Viscosity measurement & control; featuring pipe-line viscometer, temperature compensation. A. S. & R. A. Norcross, R. S. Davis Jr.

1372 Norcross, Sterling E., Kem-Feed Div., Bloomfield, N. J. Pumpless proportioner-injector. S. E. Norcross, L. D. Ferry, H. H. VanMeter, W. & M. Stickles.

843 Nordstrom Valve Div Rockwell Mfg Co., Pitts., Pa. Valve prods.

1447, 1449 North American Aviation Inc., Rocketdyne Div., Los Angeles, Calif.

1289 Norton Co., Worcester, Mass. Abrasives and associated prods., featuring prods of Electro-Chemical div.

1072 Nukem Products Corp., Buffalo, N. Y. Mfrs, designers corros-proof matls & plastics. W. J. Callopy, J. Hall, L. Flesher.

204 Oil & Gas Div Gt. Lakes Carbon Corp., New York, N. Y.

1386 Okadee Co., The, Chicago, Ill. Valves for use in chem & rubber indus of steel and crs. C. G. Learned, C. W. Ploen.

660 Omega Machine Co., Providence, R. I. Feeding & weighing machy.

1388 Orangeburg Mfg. Co. Inc., New York, N. Y. Fibre conduit, under floor duct.

996 Overstrom & Sons, Alhambra, Calif. Vibrating screens, mining machy, concentrating tables.

1266 Owens Corning Fiberglas Corp., Toledo, Ohio. Fiberglas and Kaylo industrial insulations for temp ranges from sub-zero to 1800° F. R. K. Biggers, W. B. Dias, H. K. Nickell.

1315, 1317 Pacific Valves, Inc., Long Beach, Calif.

1018 Packed Column Corp., New York, N. Y. Column packing matls. L. B. Bragg.

385 Palo Laboratory Supplies, Inc., New York, N. Y. Lab glass & equip.

681 Pangborn Corp., Hagerstown, Md. Operating models of wet and dry dust collectors. W. O. Vedder, A. L. Gardner, A. L. Buehler, J. K. Schultz.

1096 Paquet & Co Inc., New York, N. Y.

431 Parker-Hannifin Corp., Cleveland, Ohio. Fittings for instrum and proc lines. D. A. Cameron, J. G. Watson, D. J. Deakyne.

55 Parks-Cramer Co., Fitchburg, Mass. All-electric liquid phase Merrill Process System for indirect heating of ind proc. L. V. Forgues, mgr, W. J. Stewart, P. E. DeBrule.

154 Patterson Fdry and Machine Co., East Liverpool, Ohio. Conaform vac dryer, cont mixer, synth plant, ThoroBlender. E. A. Sisson, R. W. Campbell, C. G. Keirnan.

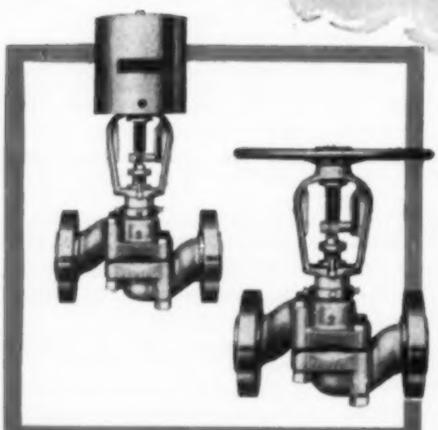
188, 215 Patterson-Kelley Co., East Stroudsburg, Pa. Lab blenders, liquid-solids twin shell production blenders, double cone vac dryers. J. J. Fischer, R. T. Dotter, H. Donaghy, D. Jaggard.

979 Peabody Engrg Corp., New York, N. Y. Operating model of industrial gas scrubber. R. Kopita, T. G. Gleason, S. Smith, J. M. Falco.

(Continued on page 110)

TOP HAND

...where Management ...Production and Maintenance are concerned!



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26th EXPOSITION OF CHEMICAL INDUSTRIES

1008 Peerless Mfg Co. Inc., Dallas, Texas. Separators for air, ammonia, oil steam, etc.

831 Peerless Pump Div Food Machy & Chem. Corp., Los Angeles, Calif. Pumps for use in chem proc ind. W. J. Blair & N. C. Olson.

969 Pennsylvania Fluorocarbon Co. Inc., Phila., Pa. Extruded flexible Teflon tubing. J. W. Burley, B. E. Ely.

1081, 1083 Perkin-Elmer Corp., Norwalk, Conn. New proc vapor fractometer. E. C. Berndt, H. McDonnell, J. Rhodes, J. O'Connell.

204 Perlite Dept., Great Lakes Carbon Corp., Los Angeles, Calif.

1384 Petrometer Corp., Long Island City, N. Y. Liquid level indicators & controls.

110, 141 Pfaudler Co., Division of Pfaudler Permutit, Inc., Rochester, N. Y. Glassed steel reactors for the proc ind. D. A. Gaudion, H. I. Edwards, J. Cosier, P. Barte.

164 Philadelphia Gear Works, Inc., Philadelphia, Pa. Operating models of fluid mixers. J. R. Connolly, mgr mixer div; H. D. McCullough, Asst.

150 Philadelphia Pump Division of American Meter Co., Philadelphia, Pa.

389 Photovolt Corp., New York, N. Y. Colorimeters, photometers, etc.

1341 Pick Manufacturing Co., Water Heater Div., West Bend, Wis. Steam injection water heaters for proc ind.

1440 Pioneer Central Div, Bendix Av. Corp., Davenport, Iowa. Fluid measuring dev., oxygen regulators, ultrasonic cleaning equip.

1146 Pioneer Division, Scott & Williams, Inc., Laconia, New Hampshire.

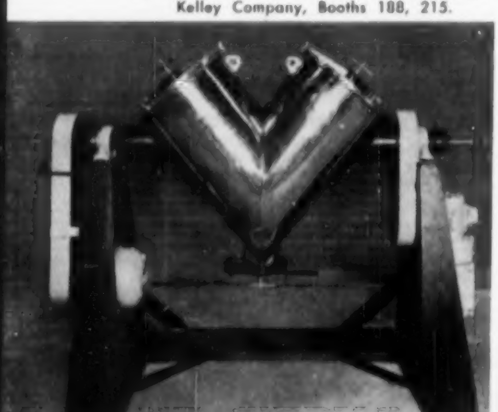
1239—Pittsburgh Corning Corp, Pittsburgh, Pa. Glass blocks, foamglas insulation.

436, 442 Plate & Welding Division, General American Transportation Corp., Chicago, Ill.

1206, 1208, 1210 Platecoil Division, Tranter Mfg. Inc., Lansing, Mich. Steam specialties.

188, 215 Pocono Fabricators Inc., East Stroudsburg, Pa.

Stainless steel liquids-solids blender: Patterson-Kelley Company, Booths 188, 215.



595 Podbielniak, Inc., Chicago, Ill. Solvent extraction centrifugal contactors, lab analyzers. W. J. Podbielniak, H. Kastruba, H. R. Kaiser.

864 Poppers & Sons, Inc., New York, N.Y. Glass.

1195, 1197 Porter Co, H.K., W-S Fittings Division, Atlanta, Ga. Roselle, N.J. Carbon, ss & alloy fittings, power tools. J. Kemper, C. J. Siebert Jr, J. H. Wyres.

396 Potter Aeronautical Corp., Union, N.J. Electronic inst. H. S. Evans, A. Toth, M. Bayer, E. Orlando.

1341 Potter and Rayfield, Inc. Stainless Tank Division, Atlanta, Ga. Presses, ovens, vac impreg equip.

980 Potts Co., Horace T., Speedline Stainless Steel Fittings Division, Philadelphia, Pa. Corros. resist. pipe & fittings.

133 Powell Co., Wm., Cincinnati, Ohio. Corros-resis valves. H. E. Coombe, D. Forker, W. E. Heilig, M. Bolinger.

904, 906 Prater Pulverizer Co., Chicago, Ill. Pulverizing machinery, rotary airlock feeders. P. E. McKamy, J. Kotilinek.

1198 Precision Chemical Pump Corp., Waltham, Mass. Chem feed pumps and control devices. C. B. Moller, R. L. Jewett, J. H. Alexander.

370, 372 Precision Scientific Co, Chicago, Ill. Lab appar.

631 Pressed Steel Tank Co., Milwaukee, Wis. Chem proc vessels, and pressure vessels, shipping containers, compr. gas cylinders, N. A. Evans, T. V. Montgomery.

1180 Pressure Products Industries, Inc., Hatboro, Pa. High pressure diaphragm compressors, high pressure shaking device, air driven pump, high pressure valves, high pressure autoclaves. R. C. Wolf, W. N. Drain, J. V. Wert, R. L. Jenkins.

684 Proctor & Schwartz, Inc.. Philadelphia, Pa. Cont drying equip. W. M. Clelland, C. A. Schoeller, H. N. Bair, R. E. Fink.

224 Productive Equipment Corp., Chicago, Ill. Vibrating screens. L. H. Lehman, V. P., L. M. Haluch, C. B. Smith, R. Martin.

1286 Protectoseal Co., Chicago, Ill. Fire prevention equip.

220 Pulva Corp., Perth Amboy, N. J. Pulverizers and feeding equip. F. Kolisek, W. W. McNamara.

632 Pulverizing Machinery Division, Metals Disintegrating Co., Summit, N. J. Line of pulverizers, Mikro-Pulsaire dust collector. R. W. MacWhorter, N. A. Hough.

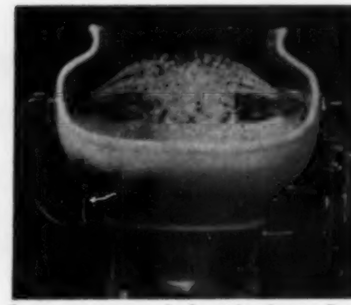
953 Quaker Oats Co., Chemicals Dept., Chicago, Ill. Levulinic acid, industrial cereals, methylfuran, methyltetrahydrofuran, gamma-valerolactone. H. R. Duffey, V. P., F. F. Mckinney, & E. A. Reineck, Sls Mgrs.

1068 Ramo Woolridge Corp., The, Los Angeles, Calif. Control dev & communic systems, computers for chem. proc. control.

820 Raybestos-Manhattan, Inc., Passaic, N. J. Packing and gasket materials. H. H. Burrows, VP, R. B. Hazard, G. E. Horvath.

1212 Raymond Corp., Greene, N. Y. Narrow-aisle industrial electric trucks.

646 Raymond Division, Combustion Engineering, Inc., Chicago, Ill. Pulverizers, mechanical air separator.



Emergency eye wash fountain: Logan Emergency Showers, Inc., Booth 883.

1435 Reaction Motors, Inc., Danville, N. J. Rockets.

162 Read Standard, Division of Capitol Products Corp., York, Pa. Heavy duty mixing and blending equip. W. J. Strandwitz, Exec VP, E. F. Munchel, C. H. McKaig, A. G. Hobba.

1285, 1287 Reeves Pulley Co., Division of Reliance Electric & Engineering Co., Columbus, Ind.

1285, 1287 Reliance Electric & Engineering Co., Cleveland, Ohio. Electric motors, generators, speed drives.

1259, 1261, 1263 Rem-Cru Titanium, Inc., Midland, Pa. Variety of prototype components and processing units. G. T. Bedford, W. J. Weeks, R. A. Matasick.

1078 Renneburg & Sons Co., Edw., Baltimore, Md. Drying and cooling systems. J. N. Renneburg, G. E. Lang.

111 Republic Lead Equipment Co., Cleveland, Ohio. Chemical lead burning & homog. lead coating.

977 Republic Seitz Filter Corp., Newark, N. J. Filters & filtration equip.

68 Republic Steel Corp., Cleveland, Ohio.

1186 Research Controls, Tulsa, Oklahoma. Miniature pilot plant valves, miniature motor-operated valves, many other types. P. M. Sanders, R. Horton, R. Posey.

889, 891 Resistoflex Corp., Roseland, N. J. Corros-resis hose, pipe, bellows, and access components. H. H. Wulff, A. N. T. St. John, T. R. Thierry.

1348, 1367, 1369 Reynolds Metals Co., Louisville, Ky. Aluminum for corrosion-resistant applications.

808, 810 Rheem Manufacturing Co., Linden, N. J. Steel barrels, pails, water heaters, dryers, air conditioning.

1151, 1153 Richardson Scale Co., Clifton, N. J. Automatic weighing machinery.

445 Richmond Manufacturing Co., Lockport, N. Y. Sifters.

1231 Reitz Manufacturing Co., West Chester, Pa. Disintegrators, screw conveyors.

1254 Robbins & Myers, Inc., Moyno Pump Div., Springfield, Ohio. Hoists, cranes, trolleys, winches, etc.

1366, 1368 Robertshaw-Fulton Controls Co., Instr Div., Phila., Pa. Bellows, temp & press. regulators, valves.

943 Rochester Mfg. Co., Inc., Rochester, N. Y. Liquid level gauges, temp. press. ammeters.

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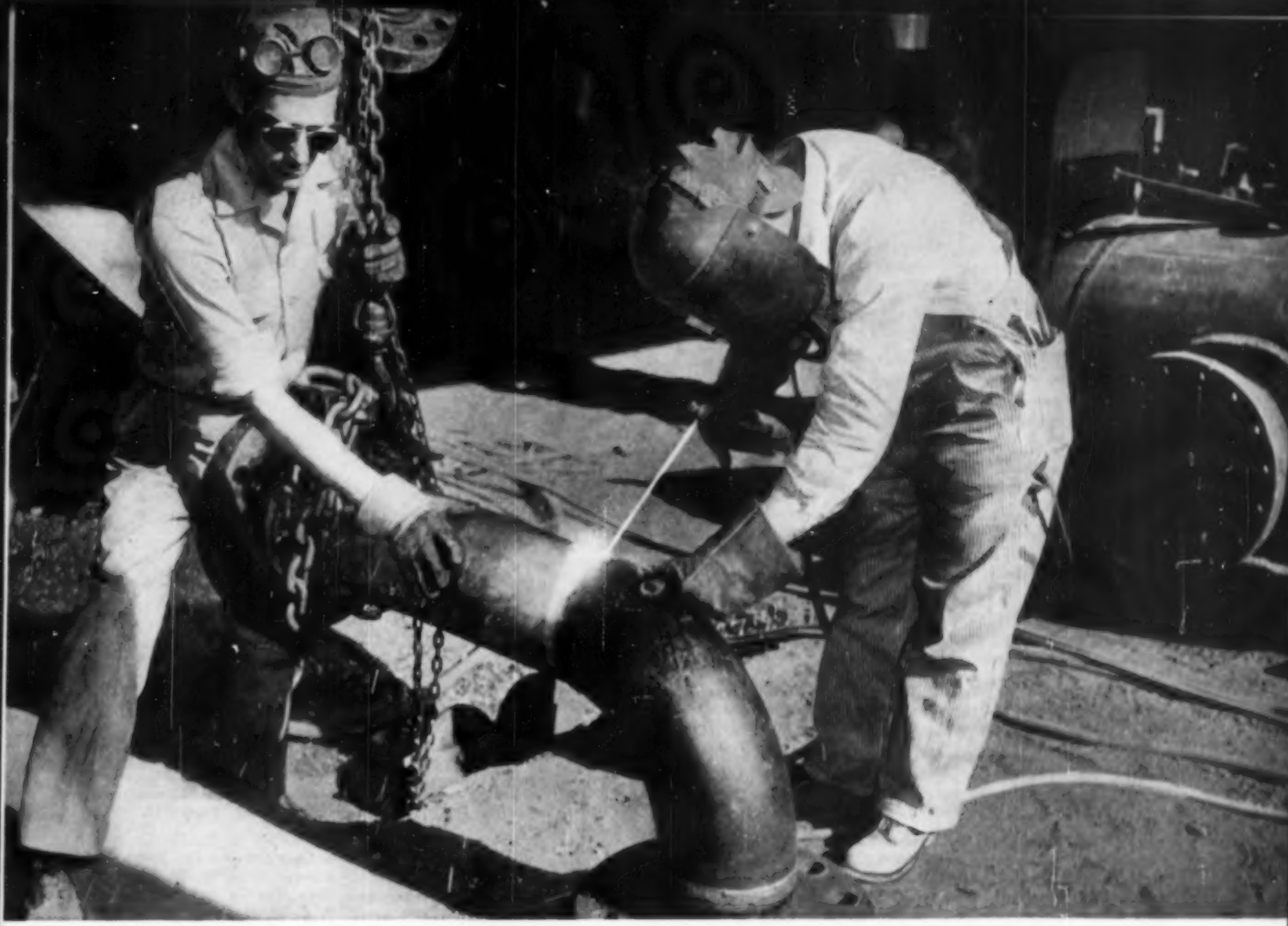

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1430 Rocket Engine Section, Flight Propulsion Laboratory Dept, Agt Div., General Electric Co., Cincinnati, Ohio. Rockets.

1240 Rodney Hunt Machine Co., Orange, Mass. Mechanically-aided thermal unit for thin-film processing of viscous fluids. C. Rasmussen, J. Ross.

843 Rockwell Manufacturing Co., Pittsburgh, Pa. Valves, lubricants, meters. H. Gottwald, W. J. Siedentopf, J. Harris, R. Miller.

1296, 1298 Rockwood Sprinkler Co., Worcester, Mass. Automatic fire sprinklers, fire alarms.

983 Ross & Son Co., Charles, Brooklyn, N. Y. Hydraulically-adjusted Three Roll Mills, Double Planetary type Change Can Mixers. L. K. Ross, C. K. Ross, J. G. Teleky, H. Surks.

123 Roth Co., Roy E., Rock Island, Ill. Regenerative turbine pumps, chem pumps, gas tanks.

582 Ruggles-Coles Engineering Co., York, Pa.

1303 Sadtler Research Laboratories, Philadelphia, Pa. End products resulting from contract development and research projects. P. Sadtler, G. Wentz, D. Tatum, R. Kelly.

645 Safety Industries, Inc., New Haven, Conn. Heavy duty centrifugal impact mill and centrifugal mixer, automatic weighing equip. R. J. Hoskins, R. F. Straw.

913 Saran Lined Pipe Co., Ferndale, Mich. Saran lined pipes, fittings, valves, and pumps. J. A. Kloustin.

163 Sarco Co., New York, N. Y. Thermodynamic steam trap. A. Milnes, R. L. Stewart, J. M. Thompson.

1375, 1377 Sargent's Sons Corp., C. G., Graniteville, Mass. Two-section pilot plant type chem dryer with pellet type extruder. R. W. Hall, Chief Eng, W. Welcome, R. D. Lambert.

1215 Schmieg Industries, Inc., Long Island City, N. Y. Dust collecting systems, indust ovens.

61 Schutte and Koerting Co., Cornwells Heights, Pa. Polyvinyl chloride fume scrubber and end fitted rotameter. F. L. Seibold, VP, J. H. Peterson, C. G. Blatchley, R. W. Eberly.

838 Schutz-O'Neill Co., Minneapolis, Minn. Mfrs. breakers, grinders, mills, granulators, pulverizers.

382 Scientific Development Co., State College, Pa.

332 Scientific Glass Apparatus Co., Bloomfield, N. J. Anschutz type Adjustatherm, automatic burettes. W. Geyer, Jr., Gen. Mgr., J. Miller, Sls. Mgr.

1293 Scientific Ind. Inc., Springfield, Mass. Ultra-Buret, microgasometer. G. Kleiman, L. Kapelsohn.

1146 Scott & Williams, Inc., Pioneer Division, Laconia, New Hampshire. Hydropulse high press pumps and Homogenizers. L. H. Brown, Ch Eng; R. C. Orton.

1102 Sealol Corp., Providence, R. I. Balanced pressure seals.

1071 Seavy & Sons, M. J., New York. 3 in. Oldershaw Column, Spinning Band Column, Concentric Tube Column, Liquid and Vapor-Dividing Still Heads. G. R. Seavy, H. G. Seavy.

973, 975 Selas Corp. of America, Dresher, Pa. Design, devel, & mfg of indust gas heat & fluid process equip.

985 Sel-Rex Corp., Nutley, N. J.

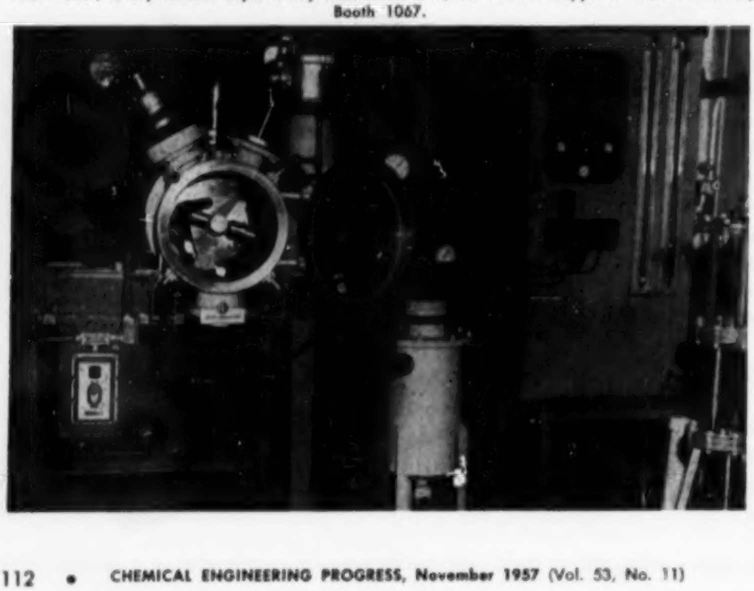
996 Separations Engineering Corp., New York, N. Y.

485 Sharples Corp., Philadelphia, Pa. Hi-cap vert decanter type centrifuge, nozzle-type, horizontal decanter type centrifuge.

336 Sheldon Equipment Co., Muskegon, Mich. Lab furniture.

473 Shriver & Co., Inc., T., Harrison, N. J. Vertical leaf filter, diaphragm pump, polymerizing reactor and slabber, plastic filter plates.

Pilot model, rotary vacuum dryer: Alloy Fabricators Div., Continental Copper & Steel Industries, Booth 1067.



Mag/Nu/Matic pneumatic transmitter: Brooks Rotameter Company, Booth 998.

806 Sier-Bath Gear & Pump Co., North Bergen, N. J. Rotary pumps (screw and gear type), gear type flexible couplings, precision gears. P. C. Renzo, R. A. Miller, J. A. Glaser.

1099 Sigmamotor, Inc., Middleport, N. Y. Pumps.

804 Simplicity Engineering Co., Durand, Mich. Vibrating screens, conveyors, feeders.

675 Simpson Mix-Muller Division, National Engineering Co., Chicago, Ill. Muller-type mixers.

73 Sly Manufacturing Co., W. W., Cleveland, Ohio. Dynaclone dust filters. C. R. Sare, A. H. Jones, E. M. Falk.

1281 Smico, Inc., Oklahoma City, Okla.

596 Smith Corp., A. O., Milwaukee, Wisc. Glascote glass-lined chem reactors, other vessel equipment, Perma-glas prods. L. T. Hickey, S. R. Stout.

986 Smith Co., The T. L., Milwaukee, Wisc. Turbine mixer. W. A. Clayton, R. P. Bremmer, R. R. Bains.

50 Snyder Tool & Engineering Co., Arthur Colton Co. Div., Detroit, Mich. Design & build machy.

1122 Sonic Engineering Corp., Stamford, Conn. Minisonic and Rapisonic homogenizers. E. C. Cottell, J. Jacobs 3rd.

1250, 1252 Southwestern Engineering Co., Los Angeles, 30 in. vibrating screen separator.

56 Sparkler Manufacturing Co., Mundelein, Ill. Plate and disc pressure-type clarifying filters. A. C. Kracklauer, P; F. H. Passalaqua, D. F. Cooper, F. M. Yeiser.

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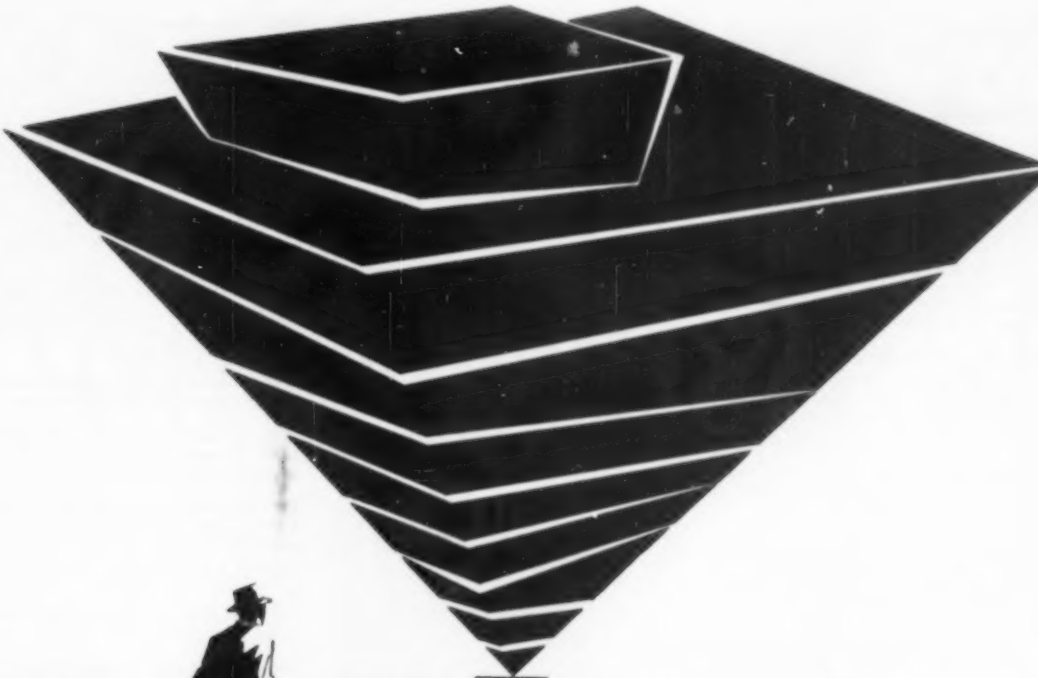

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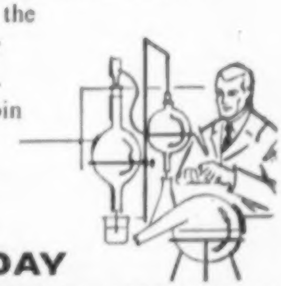

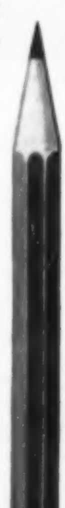

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980 Speedline Stainless Steel Fittings Division, Horace T. Potts Co., Philadelphia, Pa. Fittings. J. W. Reckard, Gen. Sls. Mfg., W. W. Morris.

1362 Sperry & Co., D. R., Batavia, Ill.

914 Spraying Systems Co., Bellwood, Ill. Spray nozzles & access.

844, 846, 848 Sprout, Waldron & Co., Muncy, Pa. Pellet mill, knife cutter, vertical mixer, 30 in. attrition mill Gyro-Whip sifter, roller mill, other materials processing and handling equip. H. M. Soars, H. J. Alsted.

1131 Standard Scientific Supply Corp., New York, N. Y. Lab specialties, "Polarotrace." J. B. McNemar, W. Lebowitz.

153 Standard Steel Corp., Los Angeles, Calif. Full-scale, commercial size rotary dryer. C. N. Roes, N. Pitt, C. C. Hopper, W. L. Nimick, E. C. McDonald.

1071 Stanford Glassblowing Laboratories, Palo Alto, Calif. Unitized spinning band column.

233 Star Tank and Filter Corp., New York, N. Y. Plate and frame filter presses, flush bottom tank valves, pilot plant reactor, fabricated stainless steel fittings. M. Burns, Sls. Mgr., N. R. Burns, Prod. Mgr.

68 Steel and Tubes Division, Republic Steel Corp., Cleveland, Ohio.

1381 Steiner-Ives Co., Union, N. J. Standard electric ovens. L. T. Ives, J. H. Dyne, R. Pounding.

1039 Stephens-Adamson Mfg. Co., Aurora, Ill. Conveying & elevating machy.

1077 Sterling, Fleischman Co., Broomall, Pa. Drum lift for controlled pouring. M. M. Fleischman, B. C. Fleischman, C. DeNault, C. Eves, E. T. Balshaw.

1104 Sticht Co., Inc., New York, N. Y. Meters.

1257 Stoffel Seals Corp., Tuckahoe, N. Y. Safety seals, identification tags.

38, 67 Stokes Corp., F. J., Philadelphia, Pa. Vacuum shelf dryers, self-contained production freezing drying system. D. E. Stokes, H. H. Brehouse, J. C. Coleman, C. E. Fantini.

815 Strahman Valves, Inc., New York, N. Y. Liquid level gauges, seatless piston valves.

1370 Straight Line Filters, Inc., Wilmington, Del.

204 Strata Products Dept., Great Lakes Carbon Corp., Houston, Texas.

1138, 1142, 1144 Strong Scott Mfg. Co., Minneapolis, Minn. Production testing service. R. R. Strong, J. T. Haigh, G. A. Carlson.

421 Sturtevant Mill Co., Boston, Mass. Air separators, Micronizer grinding machine, blenders, laboratory equipment. G. P. Towle, A. T. Glynn, D. J. Sullivan.

811 Superior Electric Co., Bristol, Conn. Variable transformers, voltage regulators, binding posts. B. G. Deming, Dist. Sls. Mgr.

1108 Superior Separator Co., Process Machinery Division, Hopkins, Minn.

1428 Surprenant Mfg. Co., Clinton, Mass. Engineered wire and cable for the electronic and aircraft industries. G. E. Forsberg, VP; R. Surprenant, G. J. Mulloney.

996 Sutton, Steele & Steele, Inc., Dallas, Texas. Laboratory separator, stoner, vibrating screen, horizontal differential screen. J. F. Sullivan, G. W. Jarman.

85 Swenson Evaporator Co., Division of Whiting Corp., Harvey, Ill. Evaporators, crystallizers, top feed filters.

948 Synthetic Mica Corp., Subsidiary of Mycalex Corp. of America., Clifton, N. J. Synthetic mica.

93 Syntron Co., Homer City, Pa. Vibratory feeders, vibratory grizzly bar screens, vibrating, screens, vibrating conveyors, vibrating spiral elevators.

Batchmaster for use in progressive weight control systems: Howe Scale Company, Booth 645.

933 Tall Oil Division, Pulp Chemicals Assoc., New York, N. Y.

1030 Taylor Forge & Pipe Wks., Chicago, Ill. Seamless steel pipe fittings, electric welded pipe.

104 Taylor Instrument Companies, Rochester, N. Y. Complete line of miniaturized process control instr.

1357 Taylor, Stiles & Co., Riegelsville, N. J. Pelletizing machines, knives, samples of cut products. J. R. Sanborn, Apgar, and Snyder.

316 Technicon Co., Chauncey, N. Y. Autoanalyzer for continuous control of proc streams by chem anal. E. C. Whitehead, VP; C. R. Roesch, Jr., A. Ferrari.

1329, 1331 Terriss Division, Consolidated Siphon Supply Co., New York, N. Y. Fabricated steelware for proc ind and corrosresis filters. D. M. Epstein, L. C. Epstein, J. Lewis.

1350, 1352 Thayer Scale Corp., Pembroke, Mass. Automatic batching systems, continuous and constant weight feeders. C. G. Peterson, F. L. Thayer, W. L. Thayer, A. M. Forsyth, R. F. West, J. Mattson.

1111 Thermo Electric Co., Saddle Brook, N. J. Transistorized temp controller, other indicating and control instruments. F. S. Walter, P, C. A. Doak, J. J. Ghiglia, B. Thomas.

1207 Thermon Manufacturing Co., Houston, Texas. New heat transfer medium. R. L. Burdick, W. E. Brown.

1442, 1444 Thiokol Chemical Corp., Trenton, N. J. Latest developments in rocket engines, and latest applications of liquid polymers. H. W. Ritchey.

1127 Thomas Flexible Coupling Co., Warren, Pa. All-metal self-aligning couplings.

1205 Thropp & Sons, Wm. R., Division of J. M. Lehmann Co., Lyndhurst, N. J. Rubber & plastic processing machy.

234 Titanium Alloy Manufacturing Division, National Lead Co., New York, N. Y. Ceramic and metallurgical proc metls containing titanium and zirconium. D. D. Wheeler, R. E. Mullady, J. G. Merriam, F. M. Stearn.

157 Toledo Scale Co., Toledo, Ohio. All types indust scales and automatic weighers.

506 Tolhurst Centrifugals Division, American Machine and Metals, Inc. Moline, Ill. 24 in. "Flex-O-Matic" continuous centrifugal. W. C. Smith, F. O'Conor, Ch. Eng., A. J. Schleich.

328 Torsion Balance Co., Clifton, N. J. Scales, balances, weights.

990, 992 Tote System, Inc., Beatrice, Nebraska. Bulk material handling systems. C. Ackerman, C. Misch, E. Pagels.

1206, 1208, 1210 Tranter Manufacturing, Inc., Platecoil Division, Lansing, Mich.

195 Trent, Inc., Philadelphia, Pa. Elect. furnaces, ovens, heating elements.

1155, 1157 Trerice Co., H. O., Detroit, Mich. Air-operated temp and press controllers. F. Z. Dahn, H. M. Trerice.

1292, 1294 Tri-Color Division, Ladish Co., Kenosha, Wis.

214 Tri-Homo Corp., Salem, Mass. Disperser and homogenizer units. T. A. Sullivan, P. Tognacci.

1392 Trinity Equip Corp., Roselle Park, N. J. Thermowells, thermocouple wells, thermometer test wells.

1251 Tripard Manufacturing Co., New York, N. Y.

1394 Trojan Electric & Machine Co., Inc., Bklyn, N. Y.

882 Troy Engine & Machine Co., Troy, Pa. Roller & colloid mills, mixers.

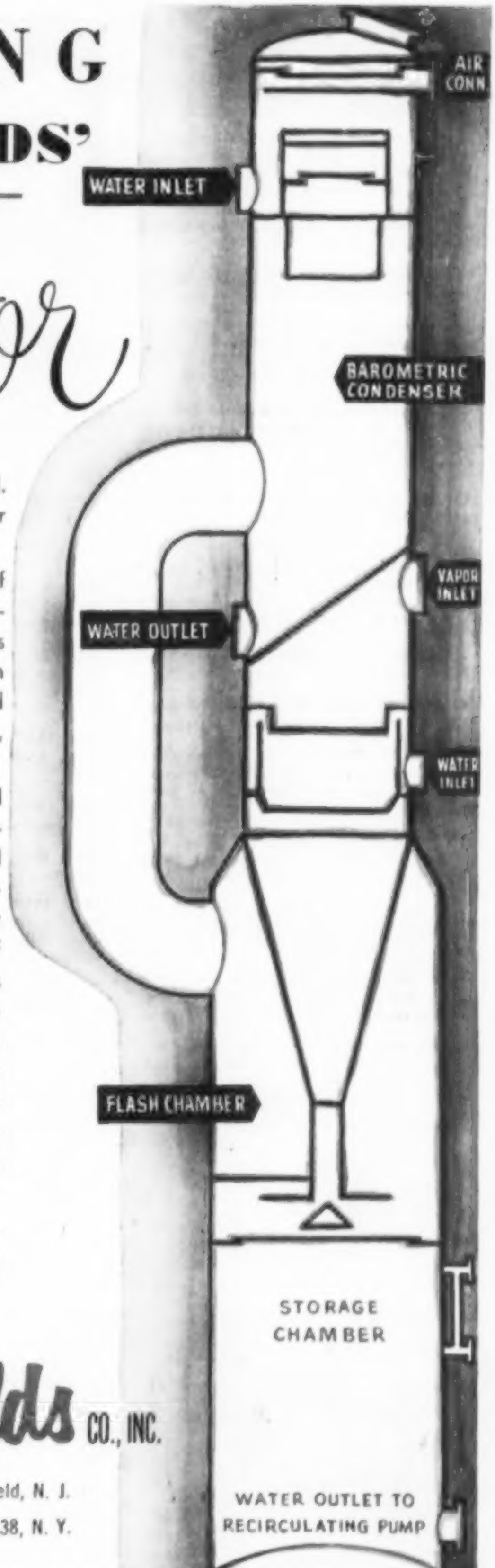
68 Truscon Steel Co., Youngstown, Ohio.

98 Tube Turn Plastics, Inc., Division of National Cylinder Gas Co., Louisville, Ky. Fittings, flanges, valves of unplasticised PVC. C. B. McLaughlin, J. W. Hendry, E. Erich.

436, 442 Turbo Mixer Division, General American Transportation Corp., New York, N. Y. Heavy-duty indust mixing equipment. Operating column of lab (4 in. diameter). E. J. Lyons, N. Parker, D. MacLean, L. Katz, D. Mayrose.

(Continued on page 116)

ANNOUNCING CROLL-REYNOLDS' NEW *Convactor*



If you never heard of a CONVACTOR, do not be surprised. It is an entirely new design of special condensing tower which offers important advantages in some processes.

In the refining of edible oils it recovers fatty acids, most of which were formerly waste. It offers the additional advantage of totally eliminating stream pollution from this source or the expense of cleaning cooling towers which collect such deposits. It has similar application in fatty acid stills, some other types of distillation processes, dryers, and other large vacuum processing units.

The CONVACTOR is a combination of two condensers and a vacuum cooling chamber. One condenser is of conventional barometric design, the other a highly improved condenser working on the jet principle. The latter condenses the vapor from the process and discharges directly into the vacuum cooling compartment where the heat of condensation is immediately removed. The cold water is then recirculated through the same jet condenser. The flashed vapor from the cooling operation is condensed in a conventional barometric condenser using water from a river, cooling tower or other industrial source. Periodic blow-down or continuous bleed-off from the flash chamber permits recovery. Several large industrial installations have been made.

It is significant that this new contribution to vacuum equipment should come the year we are celebrating our Fortieth Anniversary.

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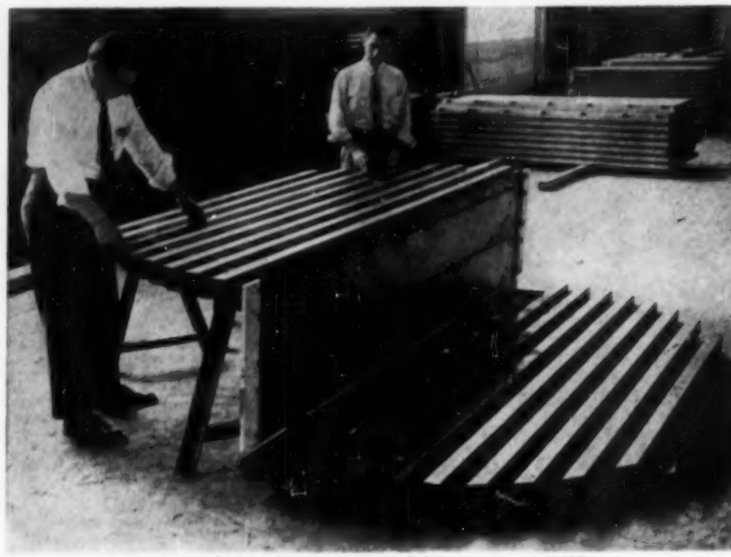
26th EXPOSITION OF CHEMICAL INDUSTRIES



Uniflex fractionating tray; Misco Fabricators, Booth 1037.

574 Tyler Co., W. S., Cleveland, Ohio. Woven wire screens & screening equip.

364 Uehling Instrument Co., Paterson, N. J. Recording & indicating instr.

68 Union Drawn Steel Division, Republic Steel Corp., Cleveland, Ohio.

1307 Union Process Co., Akron, Ohio. Attritor vertical-stirred ball mill.

840 Union Steel Corp., Union, N. J.

928 United States Borax & Chemical Corp., New York, N. Y. Organo-boron compounds and elemental boron. M. H. Pickard, G. G. Collins, R. M. Burke, L. Petterson.

837 U. S. Electrical Motors, Inc., Los Angeles, Calif. Variable-speed, multiple-drive system.

1112, 1114 United States Filter Co., El Monte, Calif. Auto-Jet pressure filter with recent innovations. L. E. Purmort, P, R. A. Trabert, H. N. Haberstroh, R. C. Foltz.

21 United States Gasket Co., Camden, N. J. Teflon gaskets, seals, packing.

495 United States Steel Corp., Pittsburgh, Pa. Alloy steels for corrosion resistance.

111 U. S. Stoneware Co., Akron, Ohio. Corros-resis coating systems, tower distributors, metal Pall Rings. Fluran plastic tubing.

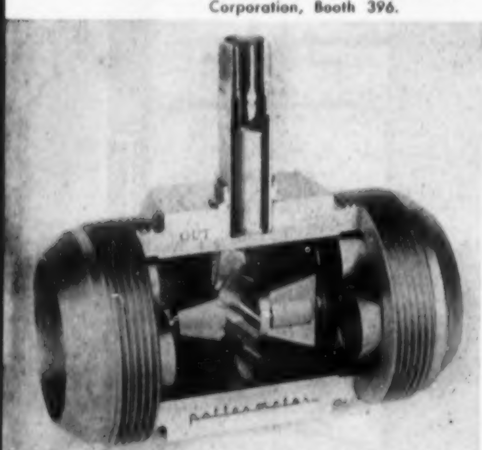
1342 Vac-U-Max, Belleville, N. J. Air-operated hi-suction vac pumps, vac-type hopper. F. P. Pendleton, H. J. Poyntz.

103 Vanton Pump & Equipment Corp., Division of Cooper Alloy Corp., Hillside, N. J. All-plastic gate valve.

1300 Velan Steam Specialties, Inc., Plattsburg, N. Y. High press steam traps and forged steel valves.

1363 Vibra Screw Co., Glen Ridge, N. J. Vibra Screw feeder. E. A. Wahl, L. Thompson, O. Lohkemper.

Automatic flow switch: Potter Aeronautical Corporation, Booth 396.



936, 938, 940, 963 Victor Chemical Works, Chicago, Ill. Eight new Chemicals including organophosphorus compounds. R. P. Gates.

124 Vogt Machine Co., Henry, Louisville, Ky. New types of gen. purp. valves. Votator continuous thermal processor for viscous fluids. W. S. Cannon, Jr., and R. F. Woolf.

1354, 1356 Voss Co., J. H. H., New York, N. Y. Compressor valves for ammonia, air & gas.

1195, 1197 W-S Fittings Division, H. K. Porter, Inc., Roselle, N. J.

1343 Walker, Crosweller and Co., Ltd., England.

1226, 1228 Wall Colmonoy Corp., Detroit, Mich. Colmonoy No. 56, a nickel-base hard-facing alloy containing chromium borides. W. P. Clark, L. C. Connolly, J. Onders, C. Ghastin.

1226, 1228 Wall-Derkiss, Inc., Linden, N. J.

1226, 1228 Wall Gases, Inc., Morrisville, Pa.

445 Wallace & Tiernan, Inc., Belleville, N. J. Pneumatic Merchen scale feeder, V-notch chlorinator, Solvay chlorine detector. S. A. Cole.

26 Walworth Co., New York, N. Y. Valves, fittings & tools.

1277, 1279 Warren Pumps, Inc., Warren, Mass. Centrifugal, rotary, reciprocating and screw pumps.

1343 Warrick Co., Charles F., Berkley, Mich. Relays & liquid level controls.

205 Welch Manufacturing Co., Chicago, Ill. Vac pumps and access. J. Gutsmiedl, R. C. Hoffman, C. Williams.

805 Welded Fittings Corp., New Castle, Pa. Large seamless fittings. A. W. Beatty, P, S. C. Carrier, D. D. Warfel, R. L. Calvin, R. A. Emery.

1353 West Instrument Corp, Chicago, Ill. Indicating & automatic control instruments.

924 West Virginia Pulp and Paper Co., Industrial Chemical Sales Division, New York, N. Y. Paper, pulp, & fiber.

510 Westinghouse Electric Corp., Pittsburgh, Pa. New line of gearmotors and speed reducers. G. Bickham.

1436 Westvaco Chlor Alkali Div, Food Machy & Chem Corp., New York, N. Y. Broad line of industrial chemicals.

46 Wheelabrator Corp., Mishawaka, Ind.

1374 Wheelco Instruments Division, Barber-Colman Co., Rockford, Ill.

85 Whiting Corp., Swenson Evaporator Co. Division, Harvey, Ill. Fndry equip, cranes, railway equip., heavy proc. equip. fabrication.

1181 Whitlock Manufacturing Co., West Hartford, Conn. Titanium and heat exchangers, weld samples. A. J. Jackson, C. J. Wahl, M. F. Savoy.

850 Wiegand Co., Edwin L., Pittsburgh, Pa. Elect. heating units.

395 Will Corporation & Subsidiaries, Inc., Rochester, N. Y. Lab equip for ind and educ chem lab. H. J. Coleman, B. C. Smith.

161 Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. Crushing, grinding, pulverizing & shredding machy.

941 Wilson Inc., Thomas C., L. I. City, N. Y. Tube cleaners, tube expanders, safety bolts & unions. O. J. Bagnoli, A. John.

1281 Wolf Co., The, Chambersburg, Pa.

695 Worthington Corp., Harrison, N. J. Centrifugal pumps. T. Davenport, R. R. Rhodes.

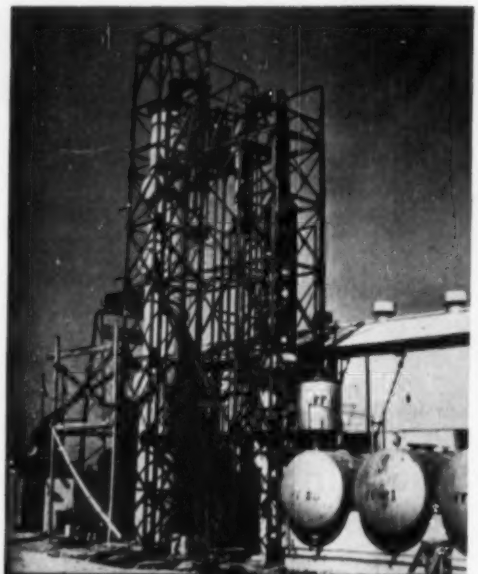
64 Yarnall-Waring Co., Philadelphia, Pa. Blow-off valves, water columns, gages.

893, 895, 897 York Corp., York, Pa. Refrigeration & air cond equip.

69 York Co., Otto H., West Orange, N. J. Full-scale Yorkmesh Demister. O. H. York, E. W. Poppele, A. A. Oliver.

1160, 1162 Young Radiator Co., Racine, Wis. "HC" Horizontal Core Atmospheric Cooler. F. M. Young, P; J. J. Hilt, A. D. Bogus, J. O'Connell.

858, 860 Yuba Consolidated Indust. Inc., San Francisco, Calif. Mining machy.



Reactor containing chlorinated organic solvents and concentrated HCl at 280°F. Duro-Line membrane protected with brick jointed with Lecite.

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Tuf-Bond — Plasticized P.V.C.
Duro-San — Polyvinylidene Chloride

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Syntho — Phenolic Resin
Duron #90 — Epoxy Resin
Duron #21 — Polyester Resin
Duron XXX — Sodium Silicate Cement
Brimsto — Sulphur Cement

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Hy-Kote — Hypolon* Base

*Trade name — E. I. du Pont de Nemours
†Trade name — Minnesota Mining & Mfg. Co.

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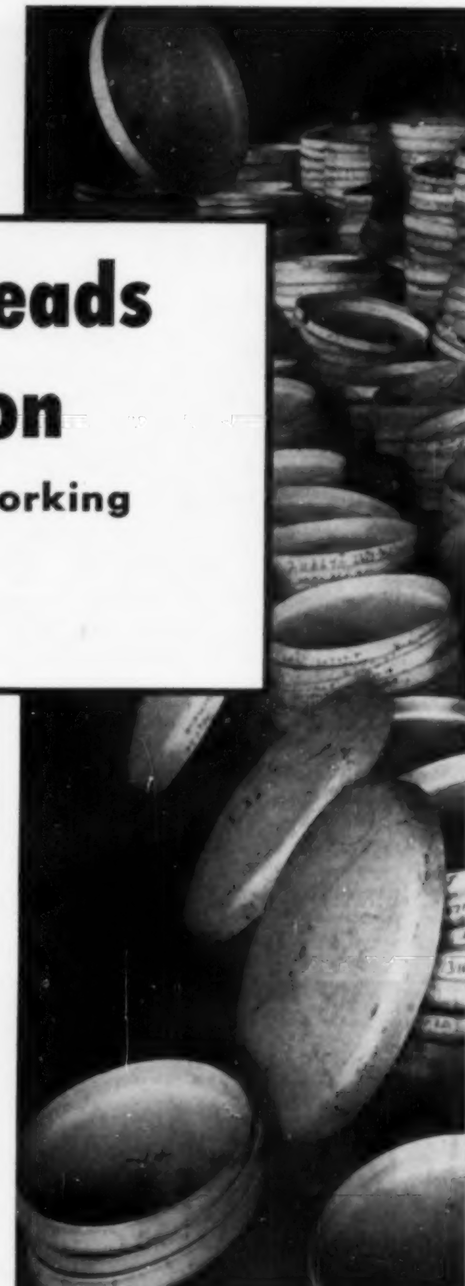

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planning for DISASTER

L. J. Grossheim
Shell Oil Company, Houston, Texas

Texas City experienced one of our country's most serious disasters on April 6, 1947, and many of us were called on for assistance in the stricken area. Initially there was much confusion in organizing our forces, for although large groups of personnel and quantities of equipment were available, a course of action was lacking. Immediate needs of caring for the dead and injured were handled quite well, but the control of the fires was not effectively started until after the second day, and this action was limited due to available water supplies. Since this experience at Texas City, other communities have had natural disasters of a similar nature which have made the people conscious not only of this possibility of man-made disasters, but also of the natural calamities, and more recently, of the possible effects of war with its atomic attacks.

Organization

In Houston and its industrial area, several attempts were made to organize an effective plan and finally, in 1954, the Houston Chamber of Commerce Fire Prevention Committee made this a project for ship channel industries. A meeting was arranged with the officials of all the channel industries and a plan was presented outlining the proposal for this organization. Our aim for this project was to accomplish three points:

1. cooperation and assistance of law enforcement groups to provide open routes of entrances and exits for authorized personnel and equipment only to disaster stricken plants or areas
2. development of the most dependable means of communications
3. a list of all available assistance in personnel and equipment which could be released by each company or organization, and development of a plan of response for mutual aid purposes to one another or to the communities.

From the beginning, the response was immediate and sincere. Representatives from each company were selected and details were worked out. When this material was completed, it was presented to all companies for approval and comment. One theme was, and still is, strictly adhered to and that is the privilege of any participant to accept or reject an appeal for aid on the basis that each location is responsible for its own protection, that no aid would be forthcoming unless specifically requested by a company, and finally, that such aid would enter the stricken plant only with the official's approval and then must act under direction of those plant officials. Our organization was designated as the Houston Ship Channel Industries Disaster Aid Group.

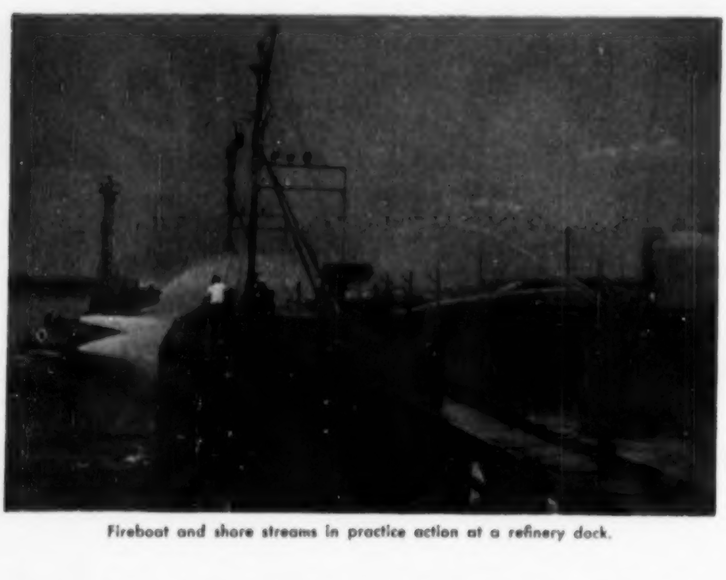
For simplicity of operations, the committee was divided into groups to handle the various phases of our activities and by prepared forms to determine the personnel and equipment available from each plant. The committee assignments were as follows:

Fire fighting—practice, with manpower and equipment from industry and municipalities
Law enforcement—lay out routes, coordinate efforts of state, county, and municipal law groups for traffic control
Rescue—first aid and medical—organize first aid: nurses, doctors, hospital facilities, ambulance services, and rescue facilities
Communications—arrange for radio network, handle news, radio, and television reporters
Engineering—provide manpower and equipment
Civil defense—develop relations and cooperation in case of emergency
Port commission—work in cooperation with U.S. Coast Guard to assist the group and advise on regulations of port.

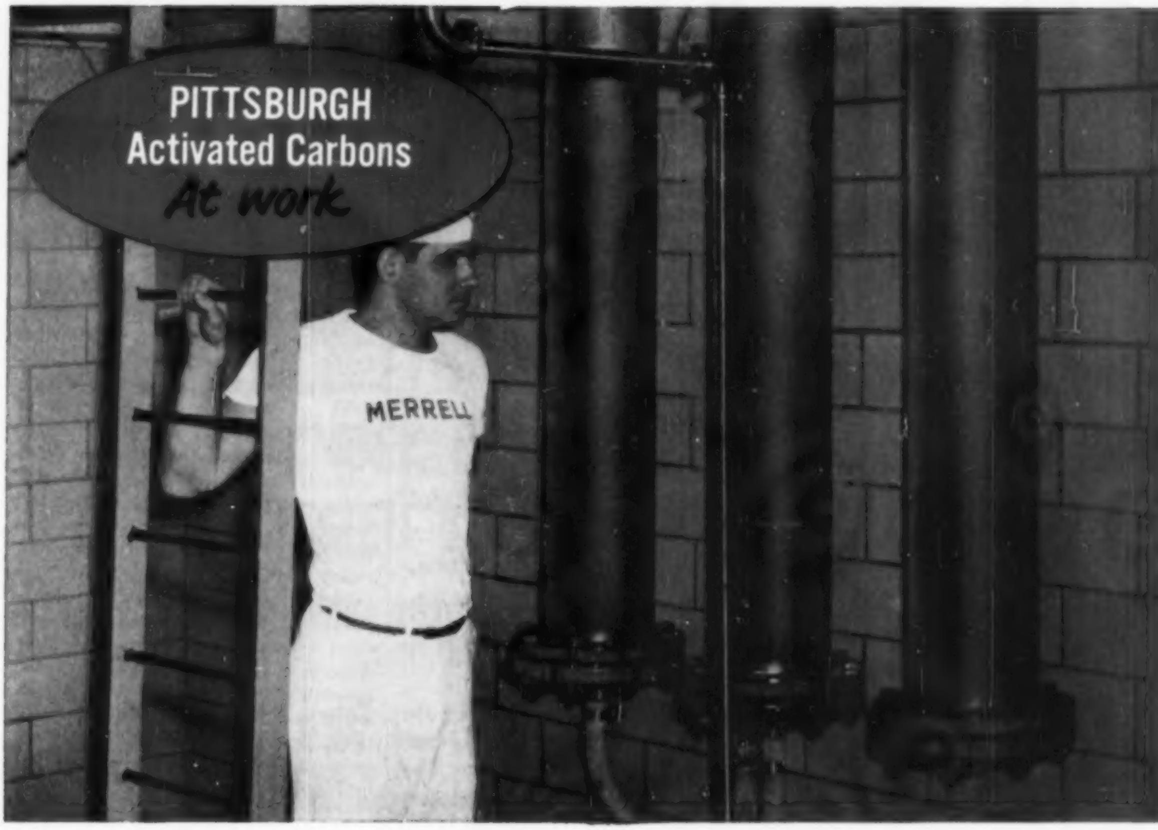
From the beginning of our organization, we determined that two services must be available to assure the effectiveness of an operation of this nature: (1) the most reliable communications system, and (2) the cooperation of the law-enforcement and fire-department groups, particularly from the municipal and county levels.

On the matter of the first requirement, namely, communication, it was decided that a two-way radio network,

(*Continued on page* 122)



Fireboat and shore streams in practice action at a refinery dock.



Decolorizing Costs Cut 75% with Pittsburgh Granular Carbon in a Column System

SEARCHING for a better way to decolorize and remove flavor from glucose-sugar solutions, the William S. Merrell Co., Cincinnati, a division of Vick Chemical Company, recently converted its batch adsorption process to Pittsburgh Granular Carbon in a fixed bed column system. Formerly, the solution, made from broken and off-size throat lozenges, was treated in slurry tanks with pulverized carbon and filtered. With its new column system, Merrell upped efficiency and reduced its processing costs 75%. Comparative cost figures are as follows:

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	Old Method	*New Method*
Direct Labor	\$11.40	\$2.50
Carbon Cost	3.90	1.98
Filter Aid Cost	1.26	—
	\$16.56	\$4.48

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DISASTER

(*Continued from page* 120)

both electrically and battery powered, would be the most practical installation. Since this involved federal jurisdiction under the direction of the Federal Communications Commission and special qualifications are required to obtain a license for use of such equipment, the local Houston and Harris County Civil Defense offered its facilities to obtain the necessary approvals. In this instance, the city of Houston applied for the license with F.C.C. and obtained authority to operate a network on a special wave length of 47.54 megacycles. The city of Houston is the licensee and each company (on a voluntary basis) purchases a two-way radio unit either fixed or mobile and executes a lease with the city without charge to use the instruments for emergency purposes only. At this time, eighteen out of thirty participants have communications units, and these are the major companies. It is important that the members of the communications committee be experienced in handling the matters of this operation as the ramifications are quite involved, particularly the requirements of F.C.C.

For the second necessary service the cooperation of the law-enforcement and fire-fighting departments of the cities and county was obtained at a joint meeting. Our plan was explained in detail and the functions of these organizations were outlined. To the credit of these officials, they subscribed wholeheartedly to our plan and offered to cooperate with us in any manner which would be in the best interests of our efforts.

In all this work, the officials of the Houston Harris County Civil Defense were of invaluable assistance. They were desirous of including our plan in their network of operations. However, while they would have jurisdiction by law in case of emergency, they realized that their lack of equipment and experience in handling an industrial emergency would seriously interfere with the success of such activities. It was finally decided that our organization would be the official representative of the Civil Defense in the Houston Ship Channel area and in direct charge of operations. On a voluntary basis, we would respond to any call from Civil Defense for assistance at another location, and in reciprocation, all the facilities of that location would be at our disposal if not active in another area. Also to the credit of these people we have enjoyed a satisfactory rela-

(*Continued on page* 124)

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

$11 MILLION ETHYLENE OXIDE-GLYCOL PLANT UNDER CONSTRUCTION FOR CALCASIEU CHEMICAL CORPORATION

Capacity to be 60,000,000 lbs./year of ethylene oxide or 8,000,000 gallons/year of glycol

Utilizing the process developed by Shell Development Company, The Lummus Company has designed and engineered, and is now constructing an $11 million ethylene oxide and glycol plant for Calcasieu Chemical Corporation at Lake Charles, La.

When construction is completed by Lummus early in 1958, the facility will be staffed and operated by 50 employees of Petroleum Chemicals, Inc. P.C.I. will also supply ethylene raw material to the new plant, from an adjacent ethylene unit designed and now under construction by The Lummus Company.

The Shell Process, which offers the advantages of unusually high yields and virtual elimination of the waste disposal problems encountered in the Chlorohydrin Process, is conducted in two steps. The first step is direct catalytic oxidation of ethylene with oxygen in fixed bed reactors. Here ethylene oxide, valuable petrochemical intermediate, is produced for use by manufacturers of detergents and other surface active agents, plasticizers, solvents, textiles, drugs and many other petrochemical compounds.

The second step of the Shell Process calls for thermal hydration of ethylene oxide to ethylene glycol, essential to manufacturers of anti-freeze, explosives, plasticizers, fibers, resins, hydraulic fluids and many more chemical products.

This is the third ethylene oxide unit currently in construction by Lummus, based upon the Shell Process. For ethylene oxide and ethylene glycol, or for any type of chemical or petrochemical plant, Lummus' half century of world-wide experience is at your disposal.

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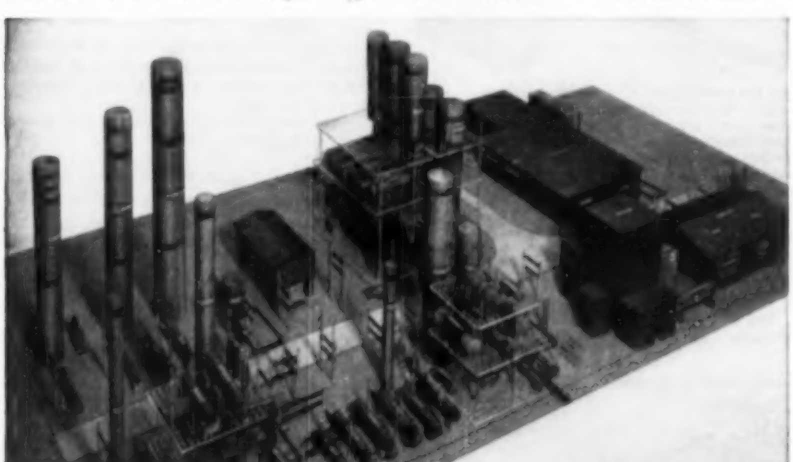


Model used by Lummus in engineering of Calcasieu Ethylene Oxide-Glycol Plant.

DISASTER

(Continued from page 122)

tionship, which is motivated by a mutual respect for one another's abilities.

Our organizational meetings in the development and preparation of material for our manual were held to an absolute minimum in order not to burden companies with excessive absences of their representatives. Every opportunity was taken to handle decisions by a mailing canvass of the industries for opinions. The contents of the manual were prepared in an effort to present a simple yet complete method of operation, and we believe that this goal was reached, an evidence of which was seen in the recommendation of the manual as a model for other industrial areas by the Industrial Division Office of Civil Defense at Battle Creek, Michigan.

Operations

In the operations of this organization, we have pursued a policy which will be a minimum of expense burden to all participants. Testimony of this is reflected in the following review of our procedures and history of activities.

The manual generally, yet directly, covers the following subjects:

Civil Defense Authority—designates authorization by local C.D. officials and personnel in charge.

Committees—lists company and organizational representatives assigned to various phases of activity.

General Regulations—covers detailed network communications regulations, company liabilities, rules of requests and response to aid, assignments of each group's activities such as fire fighting, first aid, law enforcement, communications, and engineering.

Personnel and Equipment Chart—shows personnel and equipment available from each member.

Location Map—indicates routes to be used, location and location number of each industry.

Liability—outlines the city of Houston Legal Department opinion on tort liability of respondents to official Civil Defense request for aid.

Summary—Compiles total manpower and equipment available.

Each year a survey is made among all companies to determine changes in personnel and equipment, and this information is combined with any operational revisions in printed form. Copies of this material are distributed to all members for insertion in their manuals. The companies organize their individual disaster plan after the fashion outlined in the manual; thus, we are easily integrated to augment each division of activity when responding to our alarm.

Our training drills are planned af-

fairs with hypothetical problems to be executed. These are held at least annually and extra drills will be called if necessary. However, we have found that our people are pretty uniform in their methods of emergency work and frequent drills are not necessary. We do not presume that we are well enough trained to be able to function with top efficiency, but with a minimum number of drills, we have seen evidence of improvement in coordinating our efforts as a group. Our drill operations are usually planned to coincide with the national Civil Defense annual exercise, and we work in close accord with these people. In the annual Civil Defense drill, we prepared an elaborate, hypothetical case which activated all companies and their full personnel and equipment. This was an excellent demonstration and it was particularly satisfying because of the open-door response offered by the managements of all the companies, law enforcement, fire departments, rescue corps, Red Cross, Salvation Army, boy scouts, doctors, and nurses.

We do not have regular meetings but confine such sessions to the needs when they are indicated by problems which cannot be handled by mail correspondence.

Experience

We experienced our first live alarm on February 22, 1957. A stubborn fire broke out at one of our member plants. Generally, the plan was executed satisfactorily with the necessary respondents performing their duties in an effective manner. There was definitely the appearance of a pattern being followed by respondents to the alarm and with a minimum of confusion. Like all such cases, however, there were points to be improved on and these deficiencies were properly noted both by the company involved and the other members. At a special meeting, the entire situation was reviewed and all participants presented the criticisms of their own performances which did not conform to the operations outlined in the manual. These shortcomings were all noted, and a special drill is in preparation which will illustrate the proper procedures to be followed. We do not foresee an elaborate training program for the future but expect each company to have its own personnel in a state of readiness where they will be familiar with our manual procedures. With this type of arrangement plus an annual exercise, we feel our organization should be prepared and will be effective in the execution of our ideas for an actual emergency.

Presented at South Texas Local Section meeting.

INDUSTRIAL NEWS

A complete health physics service, including initiation of radiation protection programs, is now being offered by Astra, Inc., Milford, Conn. Other services included are: hazards surveys and controls, pre-operation and operational environmental surveys, and assistance with unique health physics problems. ☐

Semi-works plants are under construction by Crawford & Russell, polymer plant engineers of Stamford, Conn., for General Electric's polycarbonate resin and for the plastics operation of Armstrong Cork Co. The company recently completed a pilot plant for G.E. ☐

Amylose and amylopectin, the principal components of potato starch, are now being marketed in this country for the first time. Marketer is the Technical Division of Stein Hall & Co., under an agreement with the producer, AVEBE of Veendam, The Netherlands. Both products are largely experimental, some uses being film forming in textiles, paper, and packaging food. ☐

Price changes on six industrial sodium phosphates have been announced by Monsanto. All are increases: monosodium phosphate anhydrous by 30 cents a hundred pounds; trisodium phosphate anhydrous by 40 cents a hundred pounds; technical grade sodium acid pyrophosphate-x by 25 cents a hundred pounds; oilfos, S.Q. phosphate, and sodium hexametaphosphate by 30 cents a hundred pounds. ☐

A significant occurrence of rubidium has been discovered in the 8 million ton spondumene (lithium) ore body now being developed by Montgary Explorations, Ltd., at Bernic Lake, Manitoba. The rubidium values are contained in a pocket of pollucite, one of the ores of cesium, now estimated at 150,000 tons. ☐

A new synthetic fiber paper has been developed by Chemstrand Corp. and Hurlbut Paper Co. The paper can be produced on conventional machinery using a new acrylic fiber developed by Chemstrand. These papers can be tailor-made, are binder-free synthetic fiber papers. ☐

Haveg Industries has acquired Lithgow Chemical Co. of California, manufacturers of a wide range of chemical corrosion resistant plastic coatings, cements, impregnations, and laminated linings. ☐

Two new titanium alloys which offer superior properties for high temperature applications are now in production on a limited commercial basis by Mallory-Sharon Titanium Corp. Because of their attractive properties, both new alloys are being extensively evaluated by the company and certain fabricators. □

Construction is near completion on the multi-million-dollar zirconium melting plant of Reactive Metals at Ashtabula, Ohio. Expected to be on stream very soon, the plant will be the largest domestic facility for the melting of zirconium. It will produce ingots and a complete line of mill products from zirconium, hafnium, and other reactive metals. The company will soon be absorbed into the new Mallory-Sharon Metals Corp. □

Lehn & Fink Products Corp., major manufacturer of drugs and cosmetics, will acquire National Laboratories, Inc., of Toledo, Ohio, a leading producer of chemicals for industrial sanitation. □

Construction of four new buildings is underway at the Norwich Pharmacal Co.'s Norwich N. Y. plant. The new buildings include a plant for the manufacture of Furoxone, one of the nitrofuran drugs developed by Norwich, a plant for the manufacture of Furacin, another nitrofuran, and a plant for nitration and acid recovery. All facilities are expected to be in operation early in 1959. □

New production facilities for exothermic ferromanganese have just been completed by Electromet (Union Carbide) at Alloy, W. Va. Production capacity has been increased six-fold. □

The first insulated sphere for the storage of liquefied butadiene at Esso Standard's Baton Rouge, La., refinery is here being covered with foamglass blocks. A built-in refrigerator at the top of storage tank is designed to keep the temperature inside the tank at 45° and maintain the quality of the butadiene. Only rarely does the storage of liquefied petroleum gases require this type of rigid temperature control.

INDUSTRIAL NEWS

New million-dollar facilities for the production of Gelvatol, polyvinyl alcohol, are in production at Shawinigan Resin Corp.'s plant in Springfield, Mass. The resin is produced by a continuous process developed by Shawinigan, is being produced in 12 different grades for specific purposes.

A new plant has been opened by Infilco, Inc., at Salem, Ill. A major equipment manufacturer, Infilco will operate a grey iron foundry at the new plant to produce castings in production quantity runs. □

American production of boron will be increased 30 per cent with the opening of the new U. S. Borax & Chemical Corp. open pit mine and refinery at Boron, Cal. The new operation is the first time boron has been mined by the open pit method. The project cost $20 million, focuses attention again on the growing importance of boron, particularly in the high-energy fuels field. □

The merger of Liquid Carbonic Corp. into General Dynamics Corp. has been approved by share owners of both firms. □

Negotiations for the purpose of exploring the desirability of a joint venture involving the production and marketing of chemicals basic to the manufacture of synthetic materials including plastics are underway between General Aniline & Film and Curtis-Wright Corp. GAF is a basic chemical producer, Curtis-Wright manufactures plastics. □

Additional supplies of pure columbium metal are now available from Fansteel Metallurgical Corp. Completion and integration of plant expansion programs have resulted in the increase, a new $6.5 million tantalum-columbium plant at Muskogee, Okla., will increase the columbium supply further when it goes on stream later this year. The metal is ductile and malleable and has high use potential in chemical plant equipment. □

Large diameter synthetic graphite electrodes for steel making furnaces are being extruded on a 2500 ton hydraulic extrusion press by Crescent Carbon Corp., Rosamond, Cal. Crescent will also produce anodes for chlorine and caustic cells, molds and special shapes for various atomic energy applications. □

A complete line of vinyl pyrrolidone polymers and copolymers is now being produced by Stein, Hall & Co., Inc. The company is equipped to tailor-make the series of resins which are promising for specialty applications in the adhesives, cosmetics, and coating fields. □

A five per cent dollar rise for sales of chemicals and allied products was predicted recently by J. O. Logan, vice president and general manager of the Industrial Chemicals Division of Olin Mathieson. Five reasons were cited by Logan: 1) general business plateau in 1958; 2) low levels of customer inventories of chemical and allied products; 3) certain industries which have slumped recently show signs of moderate recovery; 4) the chemical industry's record of capital expenditure over the past two years should be a stimulus to sales and to the development of new markets; 5) an increase in chemical prices is anticipated in 1958 which will contribute to higher dollar income. □

Scientific computation and mathematical analysis service for business and industrial organizations is now being offered by The Ramo-Wooldridge Corp., Los Angeles, Cal. A Computation Consulting and Service Bureau has been established. □

This new 1300 bbl./day Unifining Process Unit went on stream recently at the Bakersfield refinery of the Douglas Oil Co. of California. The unit, with its re-run tower for added flexibility of operation, was engineered and built by Macco Corp., Paramount, Calif. The Unifining Process itself is licensed from Universal Oil Products Co.

Impact of natural gas on the economy of the PACIFIC NORTHWEST

Carl A. Trexel, Jr. | Division of Economics Research, Stanford Research Institute

The energy base of the Northwest is being broadened by the introduction of natural gas. What will be the effect on industry? What industries may be more likely to locate in the region because natural gas is available?

To answer these questions, consider that the pattern of fuel consumption in the Pacific Northwest differs significantly from the consumption pattern for the entire United States. An examination of the data for individual sources of energy in recent years shows that petroleum and its products provide over 50 percent of the energy requirements in the Pacific Northwest; hydroelectric power provides roughly 40 percent of the requirements; and coal and wood, something less than 10 percent. In the United States, petroleum supplies about 42 percent of the total requirements, coal about 29 percent, and natural gas about 25 percent. Hydroelectric power and wood (almost negligible on a national basis) make up the difference of 4 percent. On the other hand, in California petroleum supplies 55 percent, natural gas, 36 percent, and hydroelectric power, 9 percent of the requirements. Almost no coal is used in the state.

The fact that gas is now available to the Pacific Northwest has two implications. The use of natural gas will strengthen the total energy supply position on which industrial development and diversification depend, and will help to eliminate intermittent gaps that have occurred in the past, for example, when water was not available and electricity needed to be curtailed.

The industries of the Northwest fall into four groups. Most important, and constituting 64 percent of all manufacturing in terms of production workers, are the resource-oriented industries. These are lumber, pulp and paper, and food processing. Figure 1, in showing the distribution of industry in the Northwest, portrays quite clearly how important the lumber industry (44 percent) is to the economy of the region.

A second group of industries is engaged in the further fabrication of the natural resources of the area and uses as its raw material the product of the primary processing group. An example is the furniture industry.

A third group of industries do not themselves utilize the natural resources of the area, but nevertheless exist because of these resources. They furnish the resource-based industries with supplies and machinery or utilize a by-product. The principal industries in this group have grown up around forest, fishing, and food products.

The fourth group, consumer-oriented industries—those attracted to a region to serve the local population—are underdeveloped in the Northwest because the local market has not been sufficiently large in many cases to justify establishing some of these industries. Some of the more successful of these industries in the Northwest are chemicals, fabricated metal products, and apparel.

The industries with the highest growth from 1947 to 1954 were: chemicals (238 percent), instruments and related products (178 percent), transportation equipment (49 percent), primary metals (30 percent), lumber and apparel (both 27 percent), and fabricated metal products and paper (both 21 percent). All industry increased by some 22 percent.

Very little manufactured gas was used by these industries in the 1950-1955 period; in fact, the amount used in 1955 was equivalent to approximately 0.6 billion cubic feet per year of natural gas. This was only 8 percent of total manufactured gas utilization in the region. Fuel oil, some wood, and electricity have been the predominant energy sources for this market.

Now that natural gas is available, the industrial market is expected to account for roughly 55 to 60 percent of total utility sales by distribution companies. Actually, the industrial segment of the regional total use of natural gas will be considerably higher, since direct sales by the transmission company to industry are also expected to be very substantial. In fact, reports show that industrial commitments for gas are exceeding even the most optimistic estimates of the interested gas transmission companies. It is the primary reason why there have been upward adjustments on delivery of the first gas from Canada.

Much of the industrial impact of natural gas will be simply to displace oil, and, to a lesser extent, electricity. Figure 2 shows this expected impact of natural gas on the fuel oil market in the Pacific Northwest. The bar graphs for 1950 and 1955 represent actual demand for residual and distillate fuel oils. The twin graphs for 1960 and 1965 represent potential demand for fuel oils, both with and without natural gas. It can be seen that residual fuel

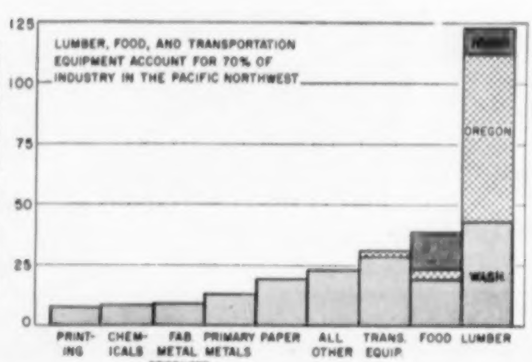


Fig. 1. The number of production workers in the Pacific Northwest categorized by industry for the year 1954.

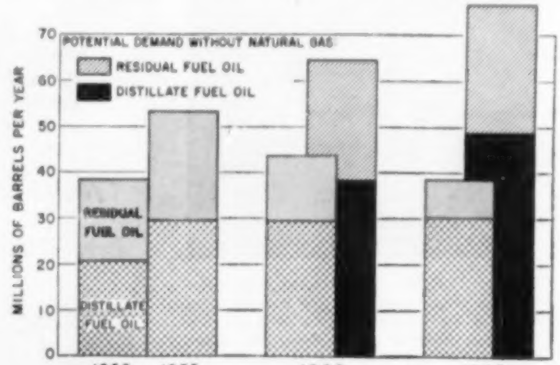


Fig. 2. Impact of natural gas on the fuel oil market in the Pacific Northwest for the years 1950, 1955, 1960, 1965.

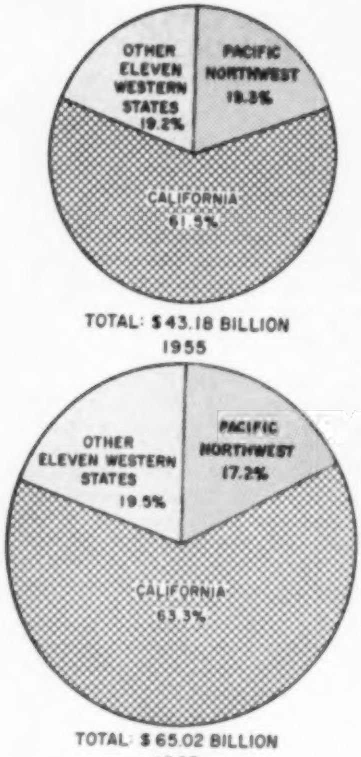


Fig. 3. Spendable income in the Pacific Northwest, California, and eleven other western states in 1955 dollars.

oil is expected to suffer the most.

Actually, the competition between natural gas and fuel oil has little bearing on industrial growth, since existing industries are served rather than new industries. To the extent that an alternative source of fuel is an advantage, however, it improves the competitive position of these industries and encourages their growth.

Industry certainly will not be attracted to the Pacific Northwest simply because this area has gas. Other areas also have gas. Nor will they come to the area because gas is cheap; it's actually cheaper in a number of other regions in the country. In some cases, however, where the chemical or heating properties of gas can be exploited fully, gas will make possible the production in the Northwest of goods for the local market which otherwise would be shipped in from another region.

The industrial fields most likely to be affected are flat glass manufacture, ceramics, chemicals, food processing, and heat treating of metals.

Whether the mere presence of natural gas will be a stimulant to growth in these industries is not certain, but it is certain that if there is any further development of these industries in the

(Continued on page 132)

NATURAL GAS IN THE PACIFIC NORTHWEST

(*Continued from page* 131)

Northwest this development will be intimately connected with gas supply.

Formerly, industrial fuel prices were considerably above those elsewhere in the West because nearly all industrial fuel, in the form of fuel oils, was supplied from California; transportation charges were added to the cost. Now natural gas can be delivered to the industrial customer in the Northwest for a price no higher than that for natural gas delivered to industrial customers in California. Furthermore, as refinery capacity builds up in the Northwest, it means that significant quantities of locally produced fuel oil will be available at prices comparable with those for fuel oil produced in California.

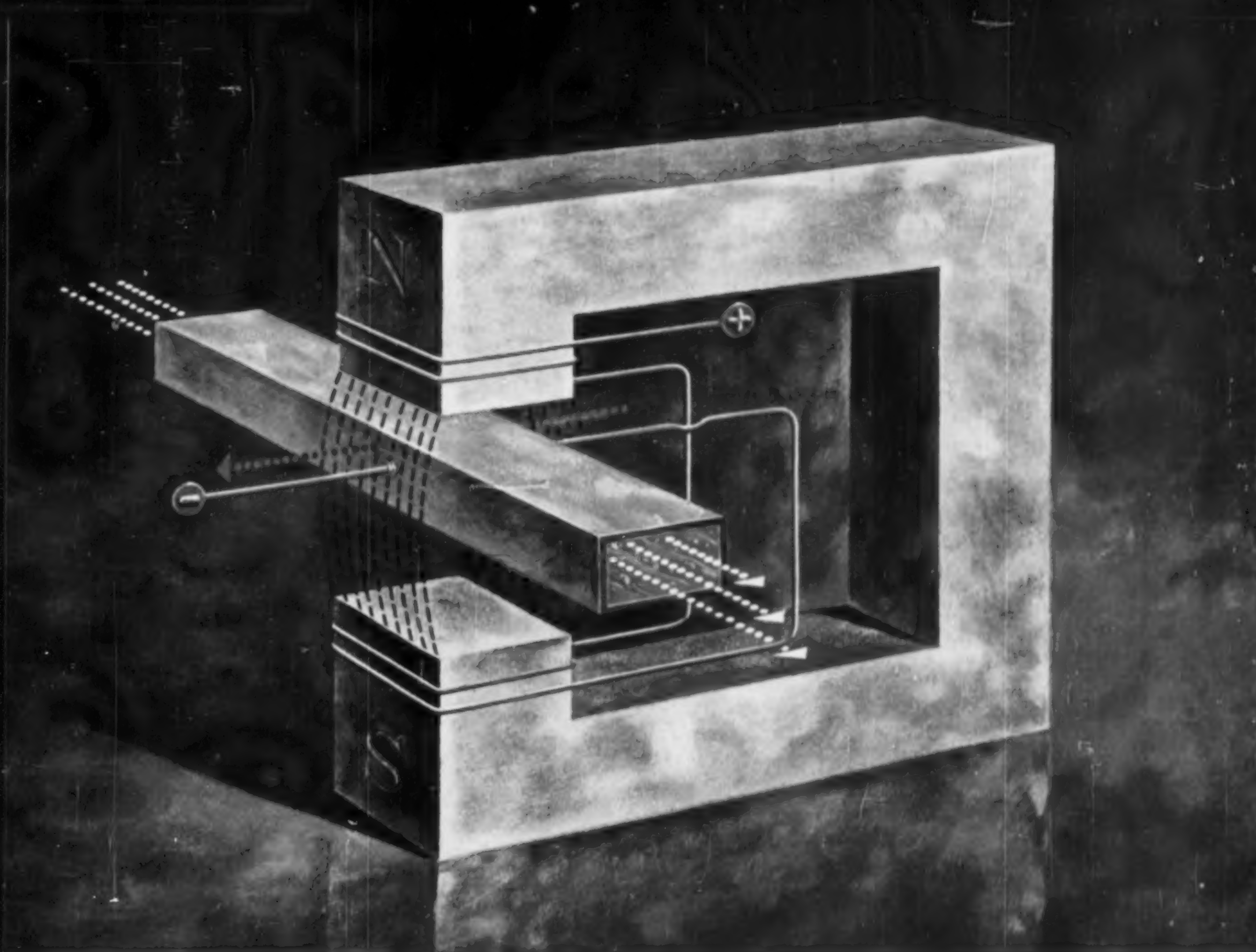
The nature and extent of the industrial growth in the Pacific Northwest during the postwar years can best be described in terms of information drawn from the 1954 *United States Census of Manufactures.* From 1947 to 1954, the number of manufacturing establishments in the Northwest increased from 7,150 to 11,780. During the same period, the number of production workers increased by over 50,000—from 230,000 to 283,000, and value added by manufacture climbed some $1.1 billion—from $1.6 billion to $2.7 billion. These increases in the Northwest are considerably above the same figures for the nation. While this region is certainly not what might be termed a highly industrialized area, it is moving steadily in that direction (Fig. 3).

It is apparent that the Pacific Northwest is rich with the promise of growth. The economic atmosphere could not be better for introducing such a vital and important fuel as natural gas to a new region.

It is no wonder that Westcoast Transmission and Pacific Northwest have recently increased their original contract by an additional 350 million cubic feet per day, making a total of 650 million cubic feet per day. This will be a north-to-south exchange, from Westcoast Transmission to Pacific Northwest. Some of this gas will replace gas which Pacific Northwest plans to sell to El Paso Natural Gas; nevertheless, a significant share will end up in Washington, Oregon, and Idaho.

During 1957, or until the Westcoast Transmission pipeline sytem is completed, Pacific Northwest will deliver natural gas to Westcoast for use in

(*Continued on page* 134)



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NATURAL GAS IN THE PACIFIC NORTHWEST

(*Continued from page* 132)

the distribution systems of B. C. Electric in Vancouver, British Columbia. It is expected that the Westcoast line will be completed in November of this year, and at that time the flow between the two gas transmission companies will be reversed. The Westcoast-Pacific Northwest contract, which is a 20-year agreement, calls for delivery from Westcoast at the international border to start at 250 million cubic feet per day prior to January 1, 1958. There seems little doubt that a relatively cheap, reliable source of thermal energy such as natural gas, when combined with the area's increasing electric power supplies, will act as an attraction to a variety of industries now considering the Pacific Northwest for the location of new plants.

Presented at A.I.Ch.E. meeting, Seattle, Washington.

A new company has been formed to participate in the Government's high energy fuel program. Named AFN, Inc., the new company is owned one-third each by American Potash & Chemical Corp., Food Machinery and Chemical Corp., and National Distillers and Chemical Corp. American Potash will operate the company and initial work will be carried out at Henderson, Nev.

AFN, Inc., has been awarded an Air Force contract covering process development and semi-pilot plant work in the high energy fuel field. The fuel will be boron-based, but further details are classified. □

A new chemical firm has been formed for the manufacture of specialty catalysts for the chemical, petroleum, and food industries. Named Catalysts and Chemicals, Inc., the new company's main offices, labs, and manufacturing facilities will be located in Louisville. □

The $70 million alumina plant of Kaiser Aluminum & Chemical Corp., located on the Mississippi River at Gramercy, La., is here receiving one of its first shipments of bauxite ore from Jamaica. The plant, which will also produce caustic soda and industrial chlorine, will go on-stream late this year.

A new million dollar polyvinyl chloride resin plant has been opened by Cary Chemicals at Flemington, N. J. The plant has a current design capacity of 12 million pounds a year but has been designed so that capacity can be doubled or tripled without difficulty. Planned and built by Scientific Design Co., N. Y., the plant will employ SD's polymerization process.

New entry into the plastic pipe field on a national basis is A. M. Byers Co. with its own line of polyvinyl chloride pipe. Two types of PVC pipe are being offered: a pure PVC that is particularly adapted to chemical and related applications; and a similar product modified with rubber for high impact strength. Broadest application is expected to be in the chemical industry. ☐

A new oxygen producing plant will be built by National Cylinder Gas Co. to supply the needs of Alan Wood Steel Co.'s new iron powder producing plant at Ivy Rock, Pa. The iron powder plant will cost $3.6 million, will have a capacity of 50 tons a day. Hydrogen requirements will be provided by Alan Wood's own coke oven gas. ☐

A new textile fiber, Zefran, is now in production by Dow. Described as a nitrile alloy, the new fiber has been tailored to fit into conventional textile manufacturing and dyeing operations used for natural fibers, is extolled by Dow for its versatility and practicality. It will be produced in commercial quantities at Dow's under-construction plant at Lee Hall, Va., will be in full production by early 1958. ☐

A branch office to improve the administration of technical services performed for Standard Oil Co. (N.J.) affiliates in Europe, has been opened by Esso Research and Engineering Co. in The Hague, Netherlands. Initially the staff will include some 15 engineers serving on rotational assignments for two years. Close contact will be maintained with Standard's affiliates to assure dissemination and prompt use of the latest research developments, and early recognition of problems. Main reason behind the move is the increasing magnitude of European construction and operation.

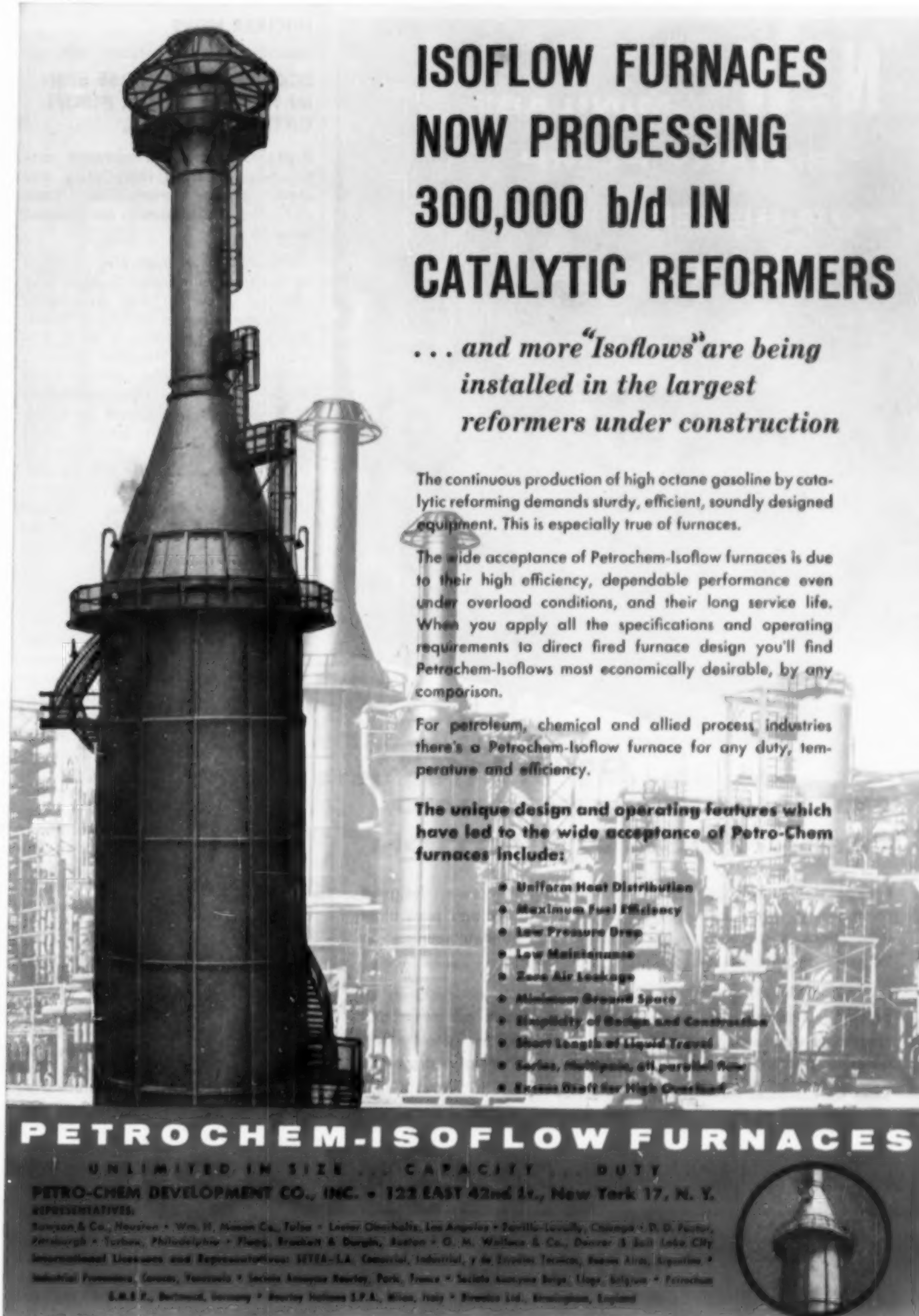
This first alkylation unit at Socony Mobil's Buffalo, N.Y., refinery is now on stream. It will produce 2,400 bbl./stream day of aviation grade alkylate from a mixture of propylene, butylenes, and isobutane contained in the 4,153 bbl./stream day of olefin liquid feed. A 7-Stage Kellogg Cascade Model B Reactor has been used in the design of the plant to produce the desired quality alkylate with a minimum of isobutane recycle. The reactor features instantaneous removal of heat of reaction, intimate and turbulent contact of isobutane, unsaturates and acid at the point of olefin feed, and provisions for the separation of the acid from reaction products. Process engineering, design, procurement and construction were handled by M. W. Kellogg.

A new oil-treated formulation of insoluble sulfur will be produced in a new unit at Stauffer Chemical's Monongahela, Pa., plant. The specially developed oil that is used is compatible with all types of rubber. The new formulation will have a specially low dusting level which will reduce the fire hazard, and has markedly superior properties in terms of ease of dispersion in rubber formulations. □

Expansion of fabrication facilities by C. G. Sargent's Sons Corp., Graniteville, Mass., has been accomplished by the purchase of buildings formerly owned by Abbot Worsted Mills. Sargent's designs and manufactures dryers and special machinery for the chemical process industries. □

Morningstar, Nicol, Inc., has acquired Federal Adhesives Corp. and all its subsidiaries. The acquisition includes Federal Latex Corp., manufacturer of rubber latex compounds, and Federal Chemicals Corp., which manufactures industrial chemicals and vinyl plastisols. □

Total investment in expansion for the current fiscal year by Dow Chemical will exceed the $162 million spent in fiscal 1957. □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ECONOMIC PROMISE SEEN IN NEW THORIUM PURIFICATION PROCESS.

Battelle-developed solvent extraction method may free nuclear power production from complete dependence on natural uranium.

Fissionable uranium-233, obtained by neutron irradiation of thorium, may play an important role in electric power generation in the United States. This was the prediction of R. B. Filbert, Jr., Battelle Memorial Institute, speaking at the recent national meeting of the American Chemical Society in New York. Foley went on to describe recent laboratory and pilot plant work at Battelle on the purification of thorium nitrate by solvent extraction.

With the new process, a recovery of 99.89% of the thorium as a purified product was achieved. Purity of the product was said to be ample for all anticipated uses in reactor experiments. Copper, an impurity originally present to the extent of 30 parts in a million parts of thorium, was reduced to less than two parts in ten million. Rare earth elements—which constitute one of the most serious reactor "poisons"— were reduced from concentrations as high as 45 parts in a million parts of thorium to as little as 2 parts in a billion, reported Foley.

Economic justification for the proposal to use thorium for reactor fuel instead of uranium-235 or plutonium-239 lies in the fact that thorium is three times more abundant in the earth's crust than uranium, is more readily obtained. With the advent of the new process, the last obstacle to the widespread use of thorium—the difficulty of obtaining the element in a sufficiently pure state—may have been surmounted.

A new company, Controls for Radiation, Inc., of Cambridge, Mass., has been organized to "provide a comprehensive package service covering the broad radiation safety and hazards control aspects of the nuclear industry." The firm will act as an independent or "third party" entity in carrying out programs of radiation control. It will lease and maintain instrumentation for monitoring radiation at or near nuclear facilities, and will make periodic determinations of radioactive content of air, ground, water, streams, vegetation, and soil collected in the environment of the installation. □

NUCLEAR NEWS

WORLD'S LARGEST ATOMIC POWER STATION PLANNED FOR ENGLAND

Work will begin immediately on a 500,000 kilowatt nuclear power station at Hinkley Point, Somerset, under a contract recently awarded by Britain's Central Electricity Authority to an atomic power project group made up of the English Electric Co., Babcock and Wilcox, Ltd., and Taylor Woodrow Construction Ltd. Overall design was by Taylor Woodrow.

The new station will have two reactors of the gas-cooled, graphite-moderated type, fueled with natural uranium. Each reactor will consist of a 24-sided core of graphite blocks with a lattice of vertical channels containing the natural uranium fuel elements, and enclosed in a spherical pressure vessel 67 feet in diameter. Electrical power output will be generated by six 93,500 kilowatt, 3,000 rev./min., hydrogen-cooled turbo-alternator sets.

Nuclear radiation will be employed in experiments designed to create or improve petroleum and petrochemical products and processes in the newly-completed radiation laboratory of Continental Oil Co. at Ponca City, Okla. Source of radiation for the studies will be fuel elements in 10-pound uranium cylinders or rods shipped to Ponca City from the AEC's Arco, Idaho, plant. □

The major 1958 trade show of the atomic industry will be held next March 17-21 at the International Amphitheatre in Chicago. The show is a consolidation of the International Atomic Exposition, formerly held in conjunction with the Nuclear Congress, and the Atomfair, held along with meetings of the Atomic Industrial Forum. The combined exposition, to be known as the Atomfair of the Atomic Industrial Forum, is the result of a cooperative effort by the A.I.Ch.E. and the Atomic Industrial Forum. □

Up to 10,000 tons per month of high-quality, low-lime uranium ore will be treated by solvent extraction methods at Vitro Uranium's Salt Lake City mill where a $2,000,000 expansion program has just been completed. Ore will be supplied to Vitro under terms of a long-term agreement (valid to March, 1962) with Jen, Inc. of Moab, Utah, owners of four claims in the Big Indian Mining District of San Juan County, Utah. □

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OVERSEAS NEWS

MORE EXPORTS, LESS IMPORTS AS JAPAN'S CHEMICAL INDUSTRY PRODUCTION TOPS PRE-WAR LEVELS

Resurgence of the Japanese chemical industry has now topped pre-war levels. The country is expected to import more fuels and raw materials in the future, will seek markets for its rising exports, according to Yuzaburo Nagai, president of Japan's Chemical Society.

The value of chemical industry production in Japan was \$680 million in 1950, had grown to about \$1.7 billion by 1956, is still going up but more slowly.

While the chemical fertilizer industry is still the most essential factor in the field, its importance is gradually declining, synthetic resins and other products are steadily increasing their position within the industry. Most spectacular development has been polyvinyl chloride. Predicted yearly production for 1957 was 80,000 tons plus, but by June production had reached a level that would give an annual production of 144,000 tons. This is a surplus, and Japan is now looking for export markets.

Synthetic fibers is another booming field, foreign exchange gained from the synthetics in 1956 was \$254 million. Total demand is still unknown, but Japan considers the situation favorable. Research and development by Japan in this field has already produced a new synthetic fiber from polyurea.

While Japan's exports of inorganic chemicals exceeded those of organics in 1952, and still do, the proportion of

(Continued on page 144)

Temporarily stationed at Phillips Chemical Co.'s synthetic rubber plant near Borger, Tex., are these nine representatives of ANIC, the Italian chemical company which is building a synthetic rubber plant near Ravenna, Italy, using the synthetic rubber process licensed by Phillips. The men are being trained in operations, engineering, and maintenance in preparation for the start-up of the Italian plant late this year. Dr. Pietro Pauletti, third from left, will be operating superintendent for the new plant which is designed to produce 33,500 tons of synthetic rubber a year.

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SYLOID AL-1
SYLOID 162
SYLOID 308

OVERSEAS NEWS

JAPANESE RESURGENCE

(*Continued from page* 142)

organic exports is going up. Nevertheless, more than half of Japan's imports are still organics.

Far To Go

Certainly, Japan's chemical industry is growing, but there are still many problems to be overcome, particularly limitations in resources.

Commercial coal production is unlikely to go above 65 million tons, oil production cannot be expected to exceed 60 million barrels a year which is only some 3 per cent of Japan's present consumption, the rest must be imported.

Today, Japan's economy depends largely on the "special demand" provided by U. S. troops still stationed there, and on U. S. foreign aid funds. But Japan knows that these artificial factors will not go on forever, and its chemical industry is working to expand production, cut the present differences between raw material cost and product price, and bring its chemical industrial pattern to the stage of importing fuels and raw materials, exporting finished products to foreign markets.

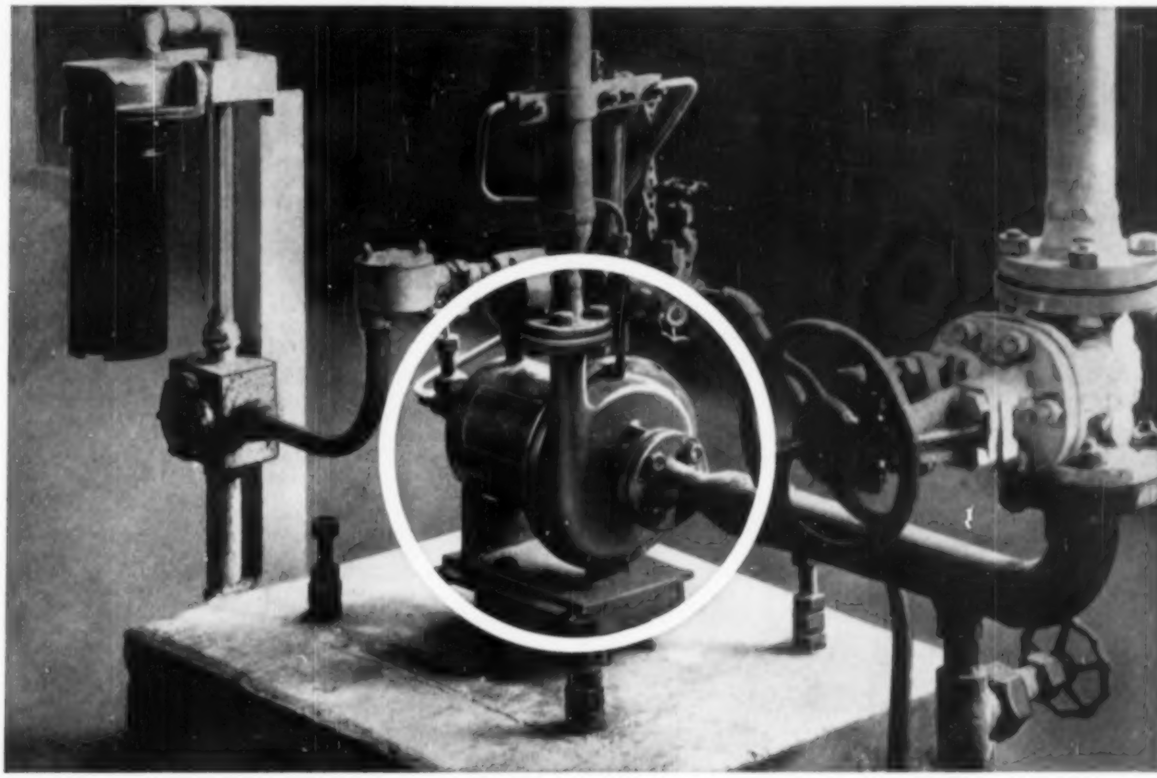
Summarized from the talk of Dr. Yuzaburo Nagai, president of the Chemical Society of Japan, given at the recent New York meeting of the ACS.

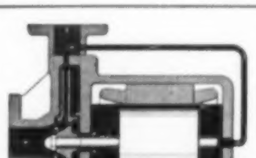
Nitroglycerine can now be produced by a new process, according to Nitroglycerin Aktiebolaget, Sweden. An injector is said to transfer the product as a non-explosive spent acid emulsion to a separate housing where the ester is removed by a centrifugal separator. It is claimed that the process has been operated successfully for a year at a rate of 1,650 lb./hr. □

A new graphite electrode plant is under construction near Monterrey, Mexico, by Electrodos Nacionales, S. A., an affiliate of Union Carbide Corp. Production is scheduled for 1958. □

Three new European sales offices have been opened by Perkin-Elmer. The new offices are in Frankfurt, Germany, Milan, Italy, and London, England. □

All outstanding stock of Cleveland Meters Ltd., England, has been purchased by Neptune Meters Ltd., of Toronto, Canada, a subsidiary of Neptune Meter Co., New York. □





EJC policy statement on . . .

AIR POLLUTION AND ITS CONTROL

C. A. Bishop | Director, Chemical Process and Chemical Engineering Development
United States Steel Corporation

In 1955 the Board of EJC approved the establishment of an exploratory group to study the implications of air pollution as related to public welfare and the responsibility of the engineering profession thereto, and report findings with appropriate recommendations to the Board of EJC.

The Committee* so formulated agreed that the engineering profession had a responsibility in the solution of air pollution problems and that a statement recognizing this fact should be prepared. One of the difficult problems was to define the expected audience. It was finally decided that the statement should be considered as a guide for those charged with the solution of the problem in their community or geographical region. It was also recognized that the statement would not be in any way a technical presentation since the engineering problems are reviewed by the various societies. The purpose was rather to focus on the over-all problem with the views of the entire profession on the broad, nontechnical policy matters and to define concisely the factors related thereto.

The Committee report was approved by the EJC Board on September 13, 1957. We trust that it will prove helpful to the many persons who are working on air pollution control.

Principles

1. The common goal is to maintain a reasonable degree of purity of our air consistent with:

a. the public health and welfare and public enjoyment thereof

b. the continued industrial development of our country

c. the protection of plant and animal life

d. the protection of physical property and other resources

2. Air pollution means the presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odor, smoke, or vapor, in quantities, of characteristics, and of duration such as to be injurious to human, plant or animal life or to property, or which unreasonably interfere with the comfortable enjoyment of life and property.

3. In the development of criteria for the control of air pollution, it must be recognized that although the atmosphere is a medium suitable for the disposal of waste products, true conservation requires that the public interest be protected against excessive and unsafe use of the atmosphere for this purpose.

4. Effective criteria are required to serve two purposes, namely, enforcement and protection of the public interest. The first of these can be most effectively accomplished at the points of emission, the second at the points of use. Sound criteria must give relative evaluation of these two measures.

5. In the development of standards, plans, rules or regulations, due consideration must be given to local conditions, such as topography, meteorology, industrial development, and area planning.

6. Emphasis should be placed upon education and voluntary cooperation by all persons and organizations who may contribute to air pollution or who are interested in its control. Encouragement should be given to groups or associations of municipalities, industries, or other groups, who severally or jointly can be of help in planning its effective abatement.

7. Laws with appropriate penalties may be necessary, but their use should be reserved for cases where cooperation and voluntary action do not prevail.

8. During an emergency, such as may develop under adverse meteorological conditions, short-time curtailment of community and industrial activities which contribute to pollution may be necessary. Although such an emergency condition is seldom encountered, it is essential that duly constituted governmental authority anticipate such a problem, and be prepared to act through a prearranged procedure.

9. The objective of air pollution control legislation is to recognize the right to the use of the air and the responsibility to avoid its abuse. It is the duty of the engineer to contribute the knowledge of his profession in the preparation of legislation that will accomplish this objective.

10. Air pollution and its control involve many scientific problems that have not yet been solved. There is no simple or quick answer. Continued research in this field is vitally necessary. The engineering profession has the obligation of reaching the best engineering solutions to these problems.

11. It is the responsibility of the engineering profession to participate vigorously in the field of air pollution control.

General Considerations

Although vast in quantity, the air surrounding the earth is, in the present development of scientific knowledge, a limited resource. It consists essentially of oxygen and nitrogen in rather definite proportion, but also contains water vapor and rare gases in varying amounts. Its oxygen is essential to life and its nitrogen, through the action of plants, provides food. Its temperature and circulation keep us comfortable and its transparency makes possible the enjoyment of natural beauty, as well as safe aerial, land and marine transportation. It serves as a filtering and diffusing medium for sunlight and other forms of radiation, reducing them to levels acceptable to plant and animal life, and it is the medium by which water is returned to the land in the form of precipitation.

The air around us, the atmosphere, is continuously exposed to both natural and artificial contamination. Every individual contributes to natural contamination by his metabolism and to artificial contamination by his activities. The activities of industry also discharge large quantities of polluting materials into the atmosphere daily. Fortunately, under most conditions, these pollutants are rapidly dispersed and diluted so that the effect is unnoticeable. It must, however, be recognized that meteorological conditions may and sometimes do exist which prevent the rapid dispersion and dilution of the polluting materials. Such conditions may result in serious air pollution and may create a public nuisance, an economic barrier to further industrial expansion and a serious health hazard.

The unprecedented expansion of industries and increase in population has caused this problem to develop before basic research essential to an adequate understanding of the many factors involved was possible. Much remains unknown relative to the direct effect of the type and concentration of contaminants or the actual mechanism by which harmful results are produced in the human body. In certain types and concentrations of pollution, relative short times of exposure have proven fatal. The effects of long times of exposure to other types and concentrations are not as yet known. There is urgent need for basic research to develop more adequate knowledge in this area.

As the air is a limited resource, its maximum use in the most efficient and economical manner is vitally important. To ignore the air's capacity to stabilize waste products or to overtax this capacity constitutes waste of a primary element in our economy, health, and welfare. The atmosphere is a natural resource that must be shared by all. Control of its pollution is a community problem. The individual must be subject to reasonable limitations on its use as may be required in the public interest.

The sources of natural pollution are many. As a result of natural phenomena, the atmosphere contains gases from the

* Members of the EJC Air Pollution Committee responsible for preparation of this statement are: ASCE—S. G. Hess; AIME—R. M. Mahoney, vice-chairman; ASME—G. V. Williamson, L. A. Winkelman (alt.); AWWA—R. J. Faust; AIEE—G. T. Minasian; ASEE—E. J. Kilcowley; ASHAE—P. J. Marschall; AIChE—C. A. Bishop, chairman; SAME—F. D. Vermilya; F. S. Mallette, committee advisor.

decomposition of animal and vegetable matter; products of volcanic and weathering action and of meteoric disintegration; spores; pollens and bacteria; and, in some sections, other vapors, gases and particulates. Generally these pollutants are absorbed or stabilized by the atmosphere.

Current technical data support the idea that the contaminants which cause serious pollution are those that result from man's own activity. The atmosphere is used as a disposal medium for man-made waste products. These wastes may be either the products of combustion or of other processes. When mixed together and subjected to sunlight and other natural phenomena, these products cause complicated reactions producing a multiplicity of secondary effects. The increase in industrial activity and in the concentration of our population has resulted in an increase in both the quantity and the concentration of such waste products in the atmosphere, a condition which often results in serious air pollution in urban areas.

In rural areas, on the other hand, pollution may result from excessive quantities of dust and vapors, both toxic and nontoxic, odors and pollen. Considerable progress has been made in the development of methods for controlling the sources of such pollution through scientific soil management and other methods of control.

While air movements disperse and dilute contaminating materials, meteorological conditions can be such that these materials may be transported with relatively little dispersion or dilution even over very great distances. Pollens, dusts and other contaminants from forest fires, wind action, volcanoes, and nuclear tests have been found in the atmosphere far from their sources. A change in meteorological conditions will cause the contaminants to settle out directly or fall to the earth with the rain or snow. As a consequence, air pollution is a world-wide problem.

To prevent detrimental concentrations of atmospheric pollutants, one must recognize what constitutes an offensive discharge and determine the allowable concentration of these constituents. Methods must then be found to keep the character and the amount of discharge under control. Most often the pollutant causing aggravation evolves from an operation in which some branch of the engineering profession is concerned. Effective and adequate control must therefore be started at the source of the pollution by engineering personnel.

Legislation at various levels of government may be desirable. Effective control can result only under legislation which is both fair and equitable, and at the same time provides for adequate penalties for violations. It must be carefully prepared and be flexible, yet specific, in order to be adjustable to the needs of all areas.

Responsible administration should start at the lowest government level capable of dealing with this technical problem. The public must be fully informed and accept the fact that each individual is both a contributor and a victim.

Causes of Pollution

Contaminating substances, both gaseous and particulate, are always present in the atmosphere. The quantity,

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AIR POLLUTION

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concentrations and characteristics of the contaminating substances found in the air at a particular time and place determine the degree of air pollution.

Air pollution from natural causes is usually of minor concern. However, volcanic gases and ashes have, on occasion, laid waste whole countrysides, and spores and pollen regularly cause distress to large numbers of susceptible people, and fogs interfere greatly with our comings and goings. These are the results of natural phenomena and at present it is difficult to mitigate these forms of air pollution. It is, therefore, the pollution resulting from man's own activities upon which the efforts of engineers presently can be most fruitfully exerted. Some idea of the complexity of the problem to be solved may be indicated by a brief listing of the major activities of people in our existing society and their contribution to the air pollution problem.

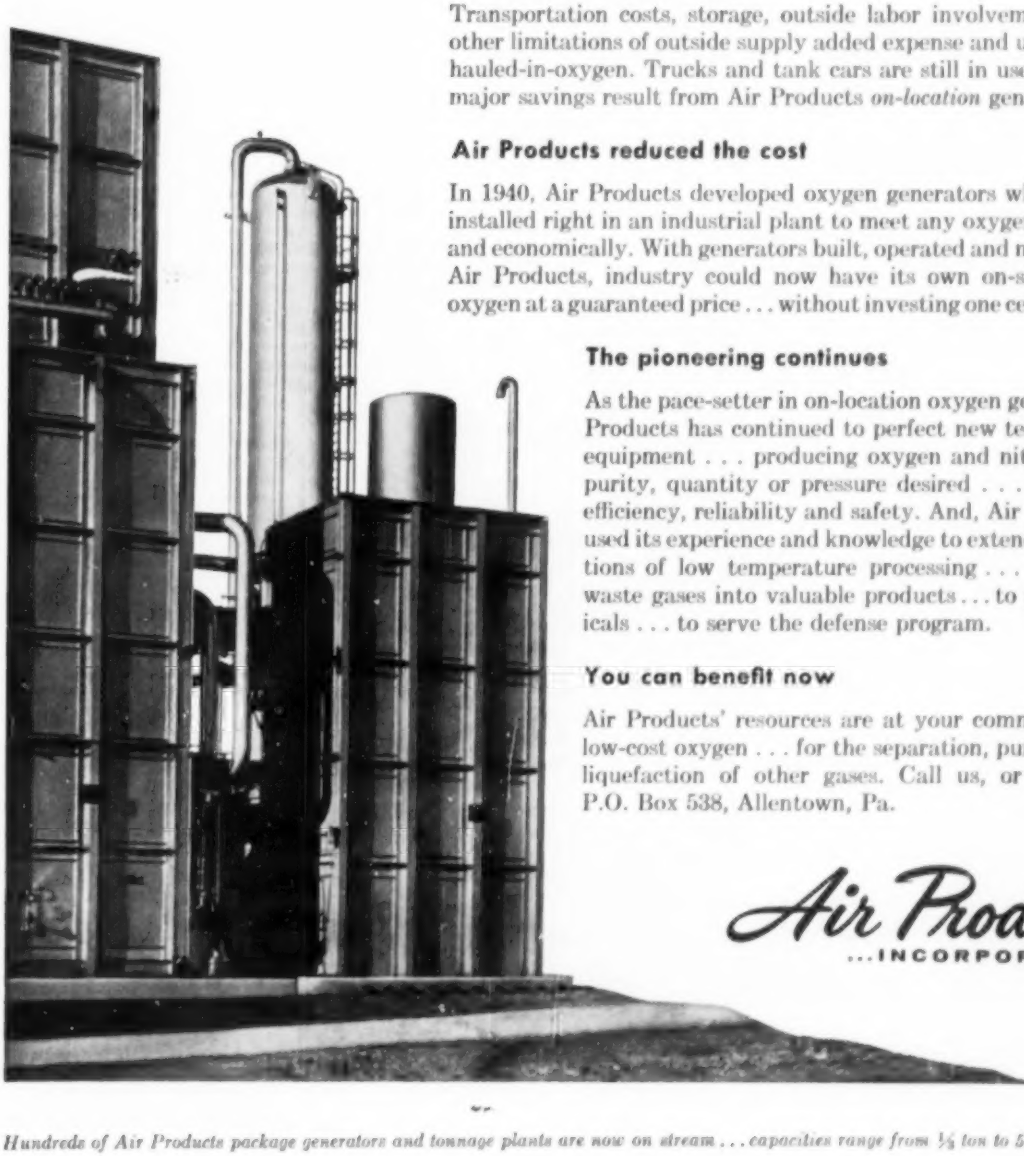
1. Agricultural activities—dusts from land cultivation, fertilization, and crop handling; odors, of both vegetable and animal origin; pollens and insecticides.
2. Commercial activities—products of combustion from fuels used for heating and cooking and from garbage and refuse disposal by open burning or incineration.
3. Construction activities—chiefly dust.
4. Domestic activities—discharges similar to those from commercial activities differing only because of size and number.
5. Industrial and manufacturing operations—products of combustion of fuels, also dusts, gases and odors arising from materials being processed.
6. Transportation—products of combustion from land, marine and air vehicles, road dust and tire dust.
7. Waste disposal—products of combustion from the burning of waste materials, either in the open or by incineration, and dusts, gases and odors from the handling of waste materials or from areas where they have been dumped.

Any of these activities can, and on occasion do, cause annoyance to people. Such annoyances can range from the effect of an improperly adjusted domestic heating furnace, which discharges soot that soils the immediate neighborhood, to an open-burning dump spreading a pall of smoke, noxious gases, and odors over a considerable area. They also include many types of commercial and industrial gases, dusts, or odors which, depending upon their quantity and characteristics, may be annoying or damaging to property.

There is another type of air pollution, which has come into prominence lately. It is a general pollution of the atmosphere above urban and metropolitan areas, which cannot be charged to a single individual or enterprise, but is a result of our complex society. The exhaust from a single automobile in proper mechanical condition is hardly observable. Yet the exhaust from two solid lines of such cars passing through a tunnel becomes so lethal that an elaborate ventilating system is required. Conditions in a narrow street, lined with tall buildings, are scarcely better unless our natural ventilating system, the wind, dissipates the fumes.

(Continued on page 150)

What happened to the price of oxygen?



The price of bulk oxygen has dropped about 80% in 12 years, while most other prices have risen. Oxygen is now being produced in large quantities for a few dollars per ton.

Oxygen isn't the high-priced chemical it used to be. Now, it's a low-priced tonnage commodity—a utility purchased like electricity or water. The price drop is the *real reason* oxygen usage has climbed beyond 70 billion cubic feet per year.

Why was it costly?

Transportation costs, storage, outside labor involvements and the other limitations of outside supply added expense and uncertainty to hauled-in-oxygen. Trucks and tank cars are still in use, but today's major savings result from Air Products *on-location* generation.

Air Products reduced the cost

In 1940, Air Products developed oxygen generators which could be installed right in an industrial plant to meet any oxygen need, safely and economically. With generators built, operated and maintained by Air Products, industry could now have its own on-site supply of oxygen at a guaranteed price . . . without investing one cent of capital.

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As the pace-setter in on-location oxygen generation, Air Products has continued to perfect new techniques and equipment . . . producing oxygen and nitrogen in any purity, quantity or pressure desired . . . with greater efficiency, reliability and safety. And, Air Products has used its experience and knowledge to extend the applications of low temperature processing . . . to transform waste gases into valuable products . . . to purify chemicals . . . to serve the defense program.

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Air Products' resources are at your command . . . for low-cost oxygen . . . for the separation, purification and liquefaction of other gases. Call us, or write us at P.O. Box 538, Allentown, Pa.

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Hundreds of Air Products package generators and tonnage plants are now on stream . . . capacities range from 1/2 ton to 500 tons per day.

AIR POLLUTION

(Continued from page 148)

Thus, above many of our major metropolitan areas, because of the congestion of population, density of traffic, and magnitude of industrial operations, an immense and ever increasing amount of contaminants is poured forth daily into the atmosphere. There they react, not only with each other, but also with the water vapor and ozone naturally present. The net result is commonly referred to as smog.

The seriousness of the condition depends on two major factors. One is a function of the total amount and characteristic composition of material being discharged into the atmosphere. The other is a function of the meteorology and topography of the region.

The effect of meteorology is pronounced. On one day the air may be clear and visibility unlimited, on the next we can scarcely see the length of a city block. Sustained winds, atmospheric turbulence, and the lack of temperature inversions all help to dissipate the man-made fog above our cities. On the other hand, windless days, a "heavy" atmosphere, and nightly temperature inversions all tend to concentrate, rather than disperse, the pollutants. If these unfavorable atmosphere conditions persist for several days, the concentration of pollutants continues to rise.

Unfavorable topography likewise induces an increase in concentration levels, by confining the polluted atmosphere and preventing its lateral movement. Valleys, or even a range of hills, are the usual unfavorable topographical features.

Methods of Control

Control of industrial and domestic pollution may be attempted in one or some combination of three ways: (1) by dilution, (2) by abolition, or (3) by treatment.

Control by dilution is an age-old method. It has been used, knowingly or unknowingly, from the beginning of time and it will continue to be used as a means of final disposal for wastes. The method has many advantages and much capacity for disposing of contaminants effectively. It fails miserably, however, when its limitations are not strictly respected. These limitations, of course, are as capricious as the winds themselves. Complete reliance on the dilution method may, under adverse weather conditions, result in nuisance or more serious conditions. By taking advantage of favorable factors, such as isolation from urban population and releases of contaminants at reasonably high elevations, however, disposal by dilution can be satisfactory.

Another method of air pollution control is abolition of the sources of trouble. No doubt this is the perfect solution, but unfortunately, its application is often restricted because of cost or impracticability. Where abolition is practical, it should be used in preference to other methods. For example, open fires, with their poor combustion possibilities and attendant hazards, should not be tolerated in most instances.

The third method of air pollution control is by treatment of the wastes to reduce their potency and other unfavorable characteristics before they are discharged into the atmosphere. This approach, in its simplest terms, is an adjunct to the dilution method; it can make the dilution method work to advantage. Many corrective methods are now available to the engineer to treat potential air pollutants. Some of the more common ones are: (1) superior combustion chambers, (2) scrubbing facilities, (3) settling chambers, (4) filters, (5) mechanical separators, (6) electrostatic precipitators, and (7) counteractants. Where applicable, each of these devices has provided a significant contribution to air pollution reduction.

Abatement of air pollution may also be accomplished by centralization of disposal functions as opposed to individual disposal. An example of this method of abatement is the collection of rubbish by a central agency from homes, apartments and commercial places for complete and adequate disposal by incineration or by sanitary land-fill method. The elimination of innumerable and inefficient individually owned incinerators by this plan, materially reduces the air pollution potential.

Many other practices and programs that were designed with other objectives in mind have helped reduce air pollution. For example, the paving or surfacing of streets and parking lots prevents the development of dust pollutions from these areas on windy days.

Thus, in most circumstances air pollution is amenable to control. Some pollution problems, however, have resisted solution and need the application of research if progress is to continue. In seek-

(Continued on page 152)

POWELL—the most complete line of Alloy Valves* for Corrosive Services

Fig. 2194—Small Ni-Resist. O.S. & Y. Gate Valve for 225 W.O.G. Larger sizes, flanged end, and swing check valves in Ni-Resist also available.

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Your local valve distributor will be glad to tell you all about them. If none is near you, write to us for the full facts on Powell Valves and Powell Engineering Service.

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Dependable Valves Since 1846
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**Powell Alloy (Corrosion Resistant) Valves are available with screwed or flanged ends. Flanged end valves conform to latest standards.*

Fig. 1832—Stainless Steel Gate Valve for 200 W.P. Screwed-in bonnet, inside screw rising stem, solid wedge disc.

Fig. 2491—Stainless Steel Gate Valve for 150 W.P. Outside screw rising stem and yoke, solid wedge disc. Can be supplied with interchangeable split wedge disc

Fig. 1559—Steel Lubricated Plug Valve for 200 W.O.G. Screwed gland type. 6" and larger valves can be furnished for gear operation.

Fig. 2433SS—Large size Stainless Steel Swing Check Valve for 150 W.P. Bolted Cap.

Fig. 2107—Stainless Steel "Y" Valve for 150 W.P. Plug type disc. Face to face and end flange dimensions conform to latest standards.

Fig. 1893—Large O.S. & Y. Gate Valve for Paper Mill Service. 3% Nickel Iron Body, bonnet, yoke; stainless steel stem, screwed-in seat rings; Ni-Resist wedge.

AIR POLLUTION

(Continued from page 150)

ing an approach to air pollution control it is not enough to identify substances from the polluted air and then seek methods of reducing the quantities of these materials. Some of them may be only the innocuous end products of reactions of unstable substances that may be the real cause of the trouble. A knowledge of the chemical components of pollutants while airborne, of the catalytic substances present, of the reactions which occur and of the shifting equilibria which are reached under varying conditions will be necessary in identifying offensive materials and in developing methods for counteracting them. To meet this and many other challenges in this field, research is required. The recovery of sulfur from stack gases and the design and development of a satisfactory home and apartment incinerator which will minimize air pollution, are typical of the problems which need solution through study.

Indiscriminate discharge into the atmosphere of waste materials which may become obnoxious or toxic, simply because no other method of disposal is known, should no longer be condoned. Scientific study and research for the satisfactory control of such discharges should precede the event rather than follow it.

The cost of air pollution abatement should be commensurate with the benefits accruing to the people. Fortunately this condition normally prevails and, because it does, air pollution control is not beyond our reach. The present thinking on pollution control leans heavily on provisions for the reduction and treatment of wastes prior to the beginning of operations at new plants. By this means, pollution can be controlled before it has a chance to do any damage.

The Engineer's Function

Engineering involves directing the forces of nature and the activities of man to his own use, convenience and welfare. In view of air pollution's causes and effects, and the technical nature of its control, the engineering profession is qualified and is duty bound to contribute substantially to the control of air pollution.

Engineers are involved, through research, development, design, construction, installation, operation and maintenance, in activities that bring into being man-made sources of air pollution. Engineers have already made substantial contributions to the solution of air pollution problems by application of technical knowledge. Many of these contributions have resulted from efforts to utilize fuels and raw materials more effectively, while others have come from efforts specifically directed to minimizing air pollution nuisances and hazards.

Other professional disciplines are contributing to effective air pollution control in many fields; these include agriculture, biology, government service, law, medicine, meteorology, politics, public health, science, and soil conservation.

The engineering profession is prepared to discharge its responsibilities in the physical control of air pollution by full participation with other professional disciplines, in establishing and effecting sound policies of control.

OVERSEAS NEWS

This plant to produce antibiotics and other drugs in Chile has been opened by Chas. Pfizer & Co. Located near Santiago, the new plant is equipped to supply all of Chile's present needs and those of other nearby countries as well.

A new company, Air Products (Great Britain) Ltd., has been organized by Air Products, Inc., of Allentown, Pa., and the Butterley Co. of London, England. The new organization will be primarily involved in design, manufacture, installation, and operation of oxygen plants and other low temperature equipment, will also produce and market industrial gases, sewage treatment equipment, and textile cleaning equipment. □

A new plant has been opened at Camberley, Surrey, England, by the Sharples Corp. of Philadelphia, manufacturers of centrifugal equipment. The new facilities, owned and operated by Sharples' wholly-owned English subsidiary, Sharples Centrifuges, Ltd., provide for substantially increased manufacturing, research, and testing. □

Further expanding its foreign operations, Archer-Daniels-Midland Co. has purchased an interst in Revalorizacion de Grasas y Aceites, S. A. (REGRASA) at Bilboa, Spain. New facilities are being installed by REGRASA to manufacture foundry core oils, other foundry supplies, and intermediate products for the paint, textile, printing ink, adhesive, lubricant, and plastics industries. These activities will be carried out under the technical supervision of Archer-Daniels-Midland. □

Petrochemicals production in Western Europe will exceed one million tons a year by 1959, according to estimates by Colin Haley of Esso Research, Ltd., Abingdon, England. Current figure is 600,000 tons. □

The Fiftieth Anniversary of Pfaudler-Werke, A. G., German subsidiary of The Pfaudler Co., Rochester, N. Y., was celebrated Oct. 18 and 19 in Schwetzingen, Baden, Germany. □

OVERSEAS NEWS

A 150 ton a day nitric acid plant will be built by Chemical and Industrial International, Ltd., Nassau, Bahamas, for the African Explosives and Chemical Industries, Ltd., at Johannesburg, South Africa. Since C & I International has the right to license all processes of The Chemical and Industrial Corp., Cincinnati, Ohio, actual design and engineering of the new plant will be done by C & I, process will be C & I's standard high-pressure nitric process. Expected to have the plant on stream by spring, 1958, African Explosives and Chemical is a subsidiary of Imperial Chemical Industries, Ltd. □

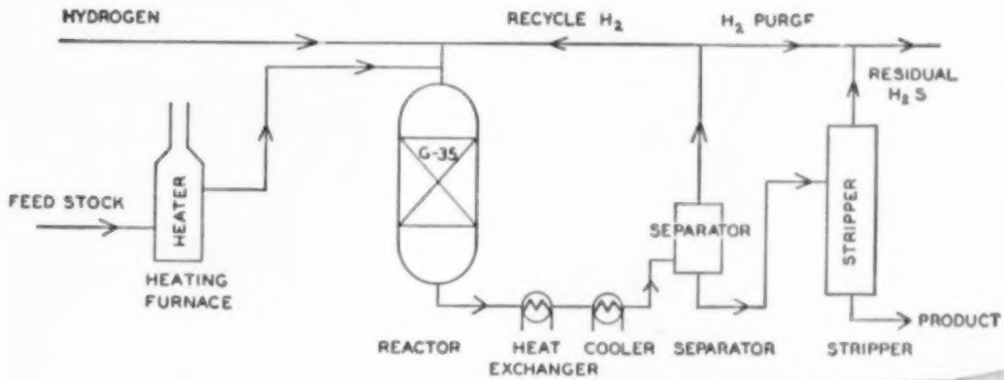
A 20,000 bbl. a day oil refinery has gone on stream at Santiago de Cuba. Built and operated by The Texas Company, the new refinery cost $15 million, includes a gasoline treating unit, a catalytic reforming unit, a liquefied petroleum gas unit, and a hydrotreater. □

A wholly-owned subsidiary has been established in London, Eng., by The Fluor Corp. To be called The Fluor Engineering and Construction Co., Ltd., the new company is expected to take advantage of the rapid rise of the petroleum industry throughout Europe. □

Technical information and "know-how" will be exchanged by Catalin Corp. of America and Cie. Centrale Rousselot, Paris, under the terms of a new five-year license agreement. The agreement provides payment for Catalin on a royalty basis, and permits Rousselot to manufacture in Sweden, Switzerland, and all NATO countries. Rousselot will also supply information to Catalin on any processes the French company develops in the areas covered. □

A polyvinyl chloride plastics plant will be built at Ahwaz, Iran, under a vast development plan being worked out by Development and Resources Corp., N. Y. It will be the first Iranian industry to utilize gas now being flared-off at the vast oil-fields around Abadan. Capacity of the plant will be 9 million pounds a year. The PVC plant and the gas pipeline on which it will be based are expected to stimulate the development of other petrochemical industries. □

Export of a research reactor to Spain has been authorized by AEC (July 29). Suppliers will be General Electric Co. of New York. □



Naphthas, middle distillates, gas oils and lube stocks can all be upgraded by hydrogen treating with the use of new Girdler G-35 catalysts. These highly active cobalt molybdenum catalysts were developed specifically for the desulfurization, denitrification and stabilization of petroleum feedstocks covering a wide molecular weight range. Typical flow diagram is shown.

Check these outstanding benefits of G-35 hydrogen-treating catalysts

G-35 HAS OUTSTANDING PHYSICAL PROPERTIES — these are retained even after extended use. Permit outstanding operational flexibility, continuous economical operation with essentially 100% yields.

IMPROVEMENT OF COLOR stability, lead susceptibility, burning characteristics and the removal of poisons from catalytic reforming feedstocks are among the more important results achieved. Girdler's expanded production facilities are geared to meet your needs for G-35 catalysts.

DETAILED INFORMATION is available on G-35 catalysts. Bulletin GC 304 discusses applications, gives process conditions for various distillate stocks, performance features and typical catalyst specifications. Free on request.

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RESEARCH NEWS

An adhesive has been developed by Bell Telephone Laboratories which will satisfactorily join polyethylene directly to rubber, brass or brass plated metals. The adhesive is so strong it will resist a pull of about 1000 pounds/sq.inch. Based on a synthetic material known as "partly hydrogenated polybutadiene," the adhesive accomplishes its bonding with heat ranging from 250° to 350° F. and pressures of 100 lb./sq.in. or less, although higher temperatures and pressures may be used.

A minimum of $120 million will be spent on research and development by U. S. Rubber Co. over the next five years. Two major goals of the vast program are: to bridge the gap between rubber and metals; to unlock the wealth of atomic energy as it applies to the rubber and chemical industries. □

Translations of nine monographs of Russian technical research have just been released by the AEC for sale to the public through the Office of Technical Services, Dept. of Commerce. □

Research on a dyeing process for blends of wool and Acrilan acrylic fiber has produced results which promise to set new standards in man-made fiber-wool blend dyeing, according to the Chemstrand Corp. □

Plans for extensive new facilities for Linde Co.'s Tonawanda Research Labs are in the works. The Union Carbide Division plans to construct a high pressure lab, a metallurgical lab, a new hydrocarbon storage building, and a new service building. The high-pressure laboratory will incorporate equipment capable of producing gas and liquid pressures up to 200,000 lb./sq. in., and with the increase in pressures available, new research work will be undertaken in the field of chemical reaction and phase transitions at high pressures. □


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RESEARCH NEWS

Conceived as the first step in the creation of a silicone technology center, this new laboratory building of the Silicone Products Department of General Electric is under construction, will include the latest equipment and facilities for the development of new silicone products. This work is part of an expansion program which will also see a sizeable increase in silicone rubber compounding capacity and a significant increase in production capacity for various silicone intermediates. Occupancy is slated for the spring of 1958.

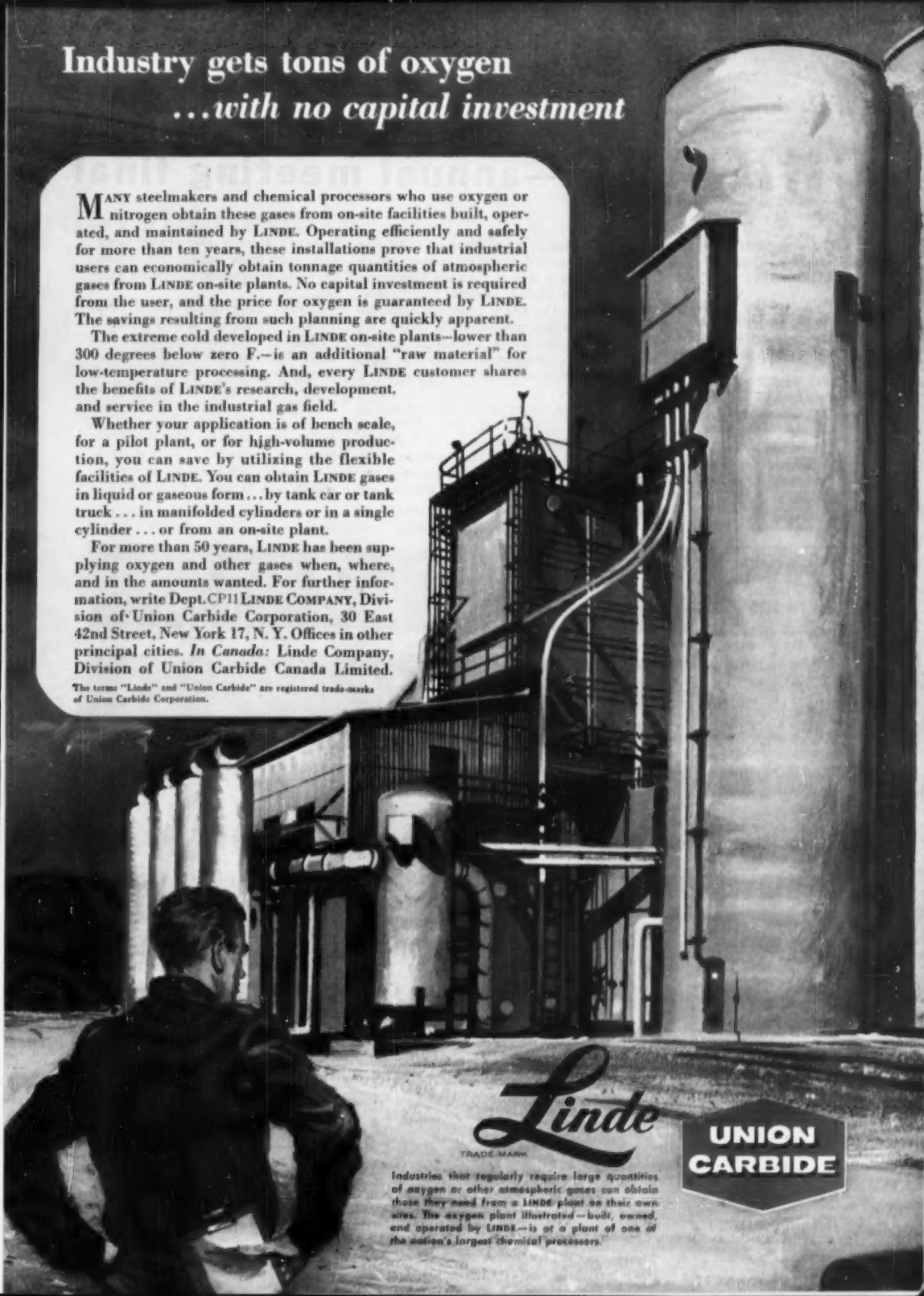
Construction of the Hooker Research Center on Grand Island, N. Y., is underway, will cost some $3.5 million, will be completed by late 1958 or early 1959. □

Coatings for niobium and the development of an inorganic laminate for radomes are the subjects of two contracts awarded to Horizons, Inc. of Cleveland by the Wright Air Development Center, Dayton. Under the niobium contract, coating techniques are to be developed for the prevention of oxidation of niobium or niobium base alloys at temperatures up to 2500° F. □

Spencer Chemical recently dedicated its new Research Center in suburban Kansas City. The new center will be devoted to research and development of new products in the general fields of agricultural and industrial chemicals and plastics. □

Construction of an integrated modern Research Center has begun by Harbison-Walker Refractories Co. on a site south of Pittsburgh, Pa. When completed next year, the million dollar project will house all of the company's research activities. At present, not only has the company expanded activities into new refractory products fields, such as mullite, silicon carbide, and zircon, but additional raw materials of great promise have been made available by the company's foreign facilities. □

A manufacturing and research-development subsidiary has been established in England by Perkin-Elmer Corp. The new company, known as Perkin-Elmer Ltd., has bought a factory at Beaconsfield, near London, where it will produce initially the company's new Infracord spectrophotometer, a low-cost infrared instrument. □



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UNION CARBIDE

CHICAGO—annual meeting final

• Governor Statton proclaims December 9 Chemical Engineers' Day in Illinois.

• Five special discussion sessions to be featured; plus a special Monday evening report on Chemical Engineering in the U.S.S.R.

• Big item on Ladies' Program: "My Fair Lady."

Innovation at Chicago will be five scheduled discussion groups which will be a sort of informal supplement to the regular sessions and symposiums. The aim is to let the chips fall where they will—no holds barred. No transcriptions or recordings will be made of these sessions and it is hoped that this will result in full and free debate.

First subject to be attacked will be *New Concepts of Unit Operations* (Monday, December 9, 2:00-4:30 PM). Is the concept of unit operations outmoded, or is it still an essential part of chemical engineering training and practice? Here is your chance to express your frank opinion and to hear the views of others on this timely question.

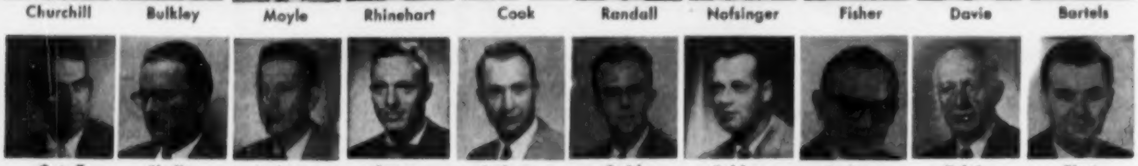
Next on the program will be *Combustion, Explosion, and Detonation* (Tuesday, December 10, 9:00-11:00 AM). This completely off-the-record discussion of explosion hazards may well bring to light actual case histories which never find their way into print—at least for public consumption. No engineer working with hazardous processes can afford to miss this one.

Cost-conscious members of the profession will be out in force on Tues-

KNOW YOUR AUTHORS

Dec. 9 Rushton Miller Myers Rose Landau Maloney Croxton

Churchill Bulkley Moyle Rhinehart Cook Randall Nofsinger Fisher Davie Bartels



Gutoff Shelley Anderson Lance Ambrose Smith Roblee Carberry Tolpin Piret

Dec. 10 Gamson Forward Koslov Arnold Mulhauser Dahlstrom Blum Pierce Peterson

West Prizer Mongan Gilfoil Mellow Lukes Hengstebeck Thodos Forman Albright

Gunnerson Metzner Higbie Zanis Mackiw Koerner Smutz Taylor H. Andrews Cummings

developments

day, December 10, 2:00-4:30 PM, for the session on *Cost Control.* While it is impossible from here to predict the course of such free debates, it is likely that company philosophies and policies will be aired freely.

When to quit? Come to the discussion on *Project Evaluation* and find out (Wednesday, December 11, 9:30-12:00 AM). How practical are the numerous more-or-less scientific approaches to the problem which have been advanced in recent years? Which method is best adapted to your particular situation and how do you go about applying it? An interesting and stimulating morning can be guaranteed.

Last subject to be tossed into the arena at Chicago will be *Productivity in Research and Development* (Wednesday, December 11, 2:00-4:30 PM). Every engineer is anxious that his abilities and training be used to the fullest extent. How far are we falling short of this goal and what can be done about improving our evaluation of productivity in creative work?

Awards

The William H. Walker Award, one of the Institute's highest honors, goes in 1957 to J. C. Elgin of the Department of Chemical Engineering, Princeton University. Presentation will be made at the Chicago Meeting. Elgin's accomplishments in the field of chemical engineering have been almost unbelievably varied: Dean since 1954 of Princeton's School of Engineering; consultant for A.E.C.; member of the

(*Continued on page* 164)

FOR YOUR WALLET

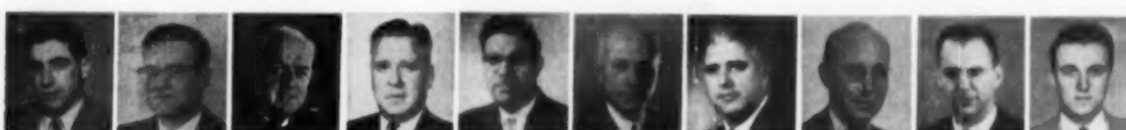
A.I.Ch.E. Annual Meeting, Chicago, Illinois, Conrad Hilton Hotel, December 8-11.

Registration: begins Sunday, December 8, 12 noon, Normandie Lounge, Conrad Hilton.

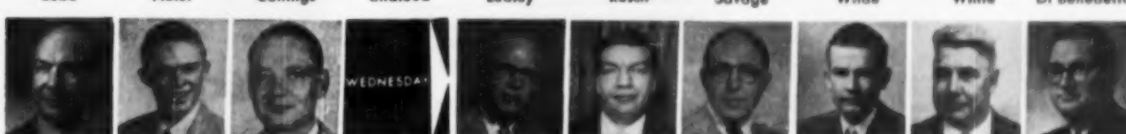
First Technical Session: 2:00 P.M. Monday.

Last Technical Session: 4:00 P.M. Wednesday.

Awards Banquet: Tuesday, December 10, 7:00 P.M., Grand Ballroom, Conrad Hilton.



Lobo, Adler, Collings, Chaloud, Ledley, Rusch, Savage, Wilde, White, Di Benedetto



Finn, Schnepf, Freeman, Dec. 11, Hubbard, De Felice, Davidson, Roberts, McGee, Gilliland

Baumgarten, Dotson, Rice, Olney, J. Andrews, Leva, Johnig, Ours, Fontana, Hennaker

Hall, Halbig, Tourtellotte, Kircher, Dunlop, Dressler, Mitchell, Akin, Bernard, Martin

Richman, Diethorn, Lamb, Foley, Bray, Parker, Happel, Overcashier, Frye, Glass

May, Huang, Radd, Bonner, Franks, O'Brien, Whitney, Han, Whitmore, Scheibel

CHICAGO MEETING

(*Continued from page* 163)

National Research Council; former director of A.I.Ch.E. His contributions to the scientific literature have included papers and articles on solvent extraction, gas absorption, rubber reclaiming, removal of sulfur from petroleum, mechanics of fluidized systems, photo-chemistry, and heterogeneous catalysis.

C. R. Wilke
Institute Lecturer

T. J. Hanratty
Junior Award

J. C. Elgin
Walker Award

V. Haensel
Professional Progress Award

G. H. Long, Jr.
Student Contest
First Prize

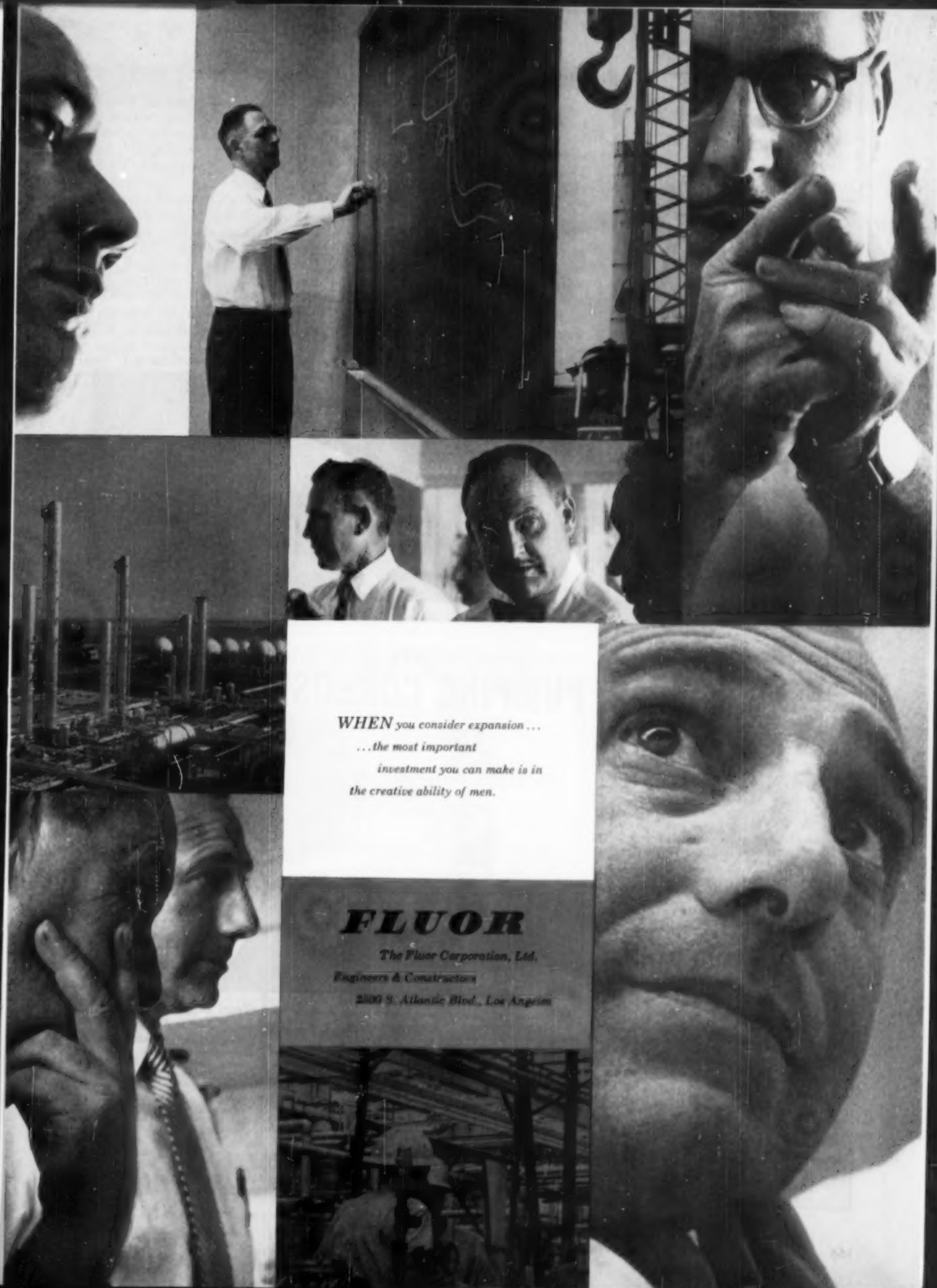
S. C. Vickers
Student Contest
Second Prize

R. M. Weiner
Student Contest
Third Prize

Key developments in the theory of mass transfer mechanisms will be the theme of the annual Institute Lecture, to be delivered this year by C. R. Wilke, professor of chemical engineering at the University of California. Wilke promises particular consideration of basic concepts and of assumptions which require further study and clarification. Recipient of the Institute's Junior Award in 1951, Wilke can draw on a long and varied career in industrial, consulting, and academic fields.

Chemical engineers at Chicago can expect a stimulating talk on *Catalysis, A Challenge to Chemical Engineering,*

(*Continued on page* 166)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investment you can make is in
the creative ability of men.
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CHICAGO—A WONDERFUL TOWN

(*Continued from page* 164)

to be given by distinguished German-born scientist Vladimir Haensel, 1957 winner of the Institute's Professional Progress Award. Haensel, an M.I.T. chemical engineering graduate, started his professional career in 1937 when he joined Universal Oil Products. In 1939, he was assigned to the Ipatieff High Pressure Laboratory at Northwestern University. At the end of World War II, Haensel inspected German synthetic oil plants as a member of the Technical Oil Mission for the Petroleum Administration for War.

This year's Junior Award winner is T. J. Hanratty, assistant professor of chemical engineering at the University of Illinois, who says that his main present interest is research in the field of fluid mechanics.

Student Contest Award winners are George H. Long, Jr. of the Process Research Division, Esso Research & Engineering (first prize); Sam C. Vickers, now with C. F. Braun & Co. in Alhambra, California (second prize); and Robert M. Weiner, presently a naval propulsion engineer in the Naval Reactors Branch of A.E.C.

Chicago's Michigan Avenue skyline and the Outer Drive. (Courtesy N. Y. Central.)

Committee on General Arrangements and Committee Chairmen for the Chicago Annual Meeting of A.I.Ch.E., December 8-11, 1957. Front row seated (l. to r.): A. A. Winkler, Publicity; R. L. Opila, Plant Tours; Miss Lois A. Bey, Ladies' Program; E. F. Wagner, Treasurer and Finance; J. E. Dlouhy, Plant Tours; and C. J. Ryant, Registration. Back row standing (l. to r.): N. L. Carr, Program Copy; C. J. Anstrand, General Chairman; S. M. Osri, Entertainment; D. A. Dahlstrom, Entertainment; W. J. Alford, Secretary; J. S. Wilson, Vice-general Chairman; P. N. Binzel, Hotel and Meeting Rooms; S. G. Sourelis, Printing; H. L. Pabich, Public Relations; W. F. Stevens, Student Program; and A. L. Wilcox, Awards Banquet.

(third prize). Honorable mention goes to R. V. Mrazek, Herbert Behrend, III, and Arthur L. Carter.

Ladies' Program

Feature of the Ladies' Program will be tickets for "My Fair Lady," matinee performance, Wednesday, December 11, 2:30 PM. A block of 200 tickets will be available on a "first-come-first-served" basis, so get your reservation in early. Other musts for the fair sex are the Sunday Get Acquainted Gathering and the Tuesday Awards Banquet. Bus tours of Chicago's North and South Sides have been arranged as well a special luncheon at Chicago's famous Swedish restaurant, the Kungsholm. Several plant tours will also be open to the ladies.

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SAFETY INFORMATION EXCHANGE MAKES MAJOR STRIDES AT MEETING

The extremely rapid growth in the last four years of numbers of ammonia plants and large air distillation plants in the petrochemical and chemical industry has been accompanied by some disastrous fires and explosions. In most cases the real causes are still not confidently known. Many informal small meetings and conversations have taken place between representatives of two or three companies at a time and the feeling grew that some means should be developed whereby all companies having such plants could discuss mutual problems and pool information relating to the safety aspects of these operations.

The writer, with the active cooperation of the A.I.Ch.E. National Program Committee, Roy Kinckiner (Du Pont), James I. Harper (Sun Oil), William T. Dixon (Atlantic Refining), Harold E. Maune (Mississippi River Chemical), and many others, developed a proposal to hold a two-day symposium, this to be set up as a group discussion with a preannounced agenda at one of the A.I.Ch.E. national quarterly meetings. The presentation of a paper by Kerry of American Air Liquide on *Safe Design and Operation of Air Plants* at the December, 1956 A.I.Ch.E. Boston Meeting gave an opportunity to feel the pulse of the industry on such a proposal and the discussion period following the Kerry paper indicated that it would be well received. Accordingly, A.I.Ch.E. accepted the proposal, although it is a radical departure from their normal meeting practice, and the symposium was scheduled for the Baltimore meeting, September 17 and 18, 1957.

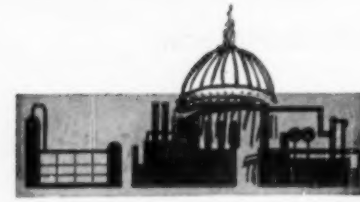
Over 90 per cent of the ammonia plants in the United States, Canada, and Puerto Rico had representatives in attendance, as well as the major designers of air plants.

The mechanism of using a preannounced agenda, with a short introduction on each item by an authority in the field, followed by discussion from the floor, worked very well. There was excellent participation in the discussion. Harold Maune of Mississippi River Chemical Company presided at the ammonia plant session and the writer at the two air plant sessions.

Following the ammonia plant session an invitation to meet later in the afternoon was issued to those who might be interested in holding such symposiums at some regular intervals.

(*Continued on page* 174)

RESEARCH—front page news . . .



Joseph L. Gillman, Jr.

• Criticism of Government research and development policies is rising sharply, particularly in the missile field.

• Return to civilian-headed Government R & D effort, with Cabinet status, urged by Senate leader.

Sputnik has suddenly made the entire world aware of what engineers and scientists have been shouting about, unheeded by the public, for decades—research yields results.

Judging by the agitation in Washington these days, the successful launching of the Soviet satellite has done more for the economic welfare of technology and technologists than all the previous efforts of organized science. Research is now front page news.

Our entire Government R & D effort is coming in for angry words—witness the now famous order of Defense Secy. Wilson which has been interpreted as cutting vital R & D effort by 10 per cent, is being pointed to as a prime example of research-stifling administration. The trouble is that in many cases it is difficult to say just exactly what is happening in our R & D effort. Wilson's order is obscure, many of those who have to abide by it and administer it admit they don't understand it. Here is one sentence from the now famous order:

"Those programs will therefore be adjusted to the extent necessary to reduce support requirements under Procurement and Production appropriations by a total amount not less than 10% of the Fiscal Year 1958 Research and Development appropriations for each department and such requirements will then be funded under Research and Development appropriations."

Criticism and Plans

Senator A. S. (Mike) Monroney (*D.Okla.*), who was in Europe when Sputnik startled the world, has been outspoken in his criticism. During an informal conference in his office he expressed his opinion this way:

"By being first with entering space, they got an advantage. I don't think producing another satellite 'me tooing' in December or March will recapture the imagination or the advantage. We've got to get a better ICBM, put our programs together. We can't have three compartmented efforts. A balanced defense at this time is more important than a balanced budget."

Subsequently, in a letter to the President, Senator Monroney stated: "Certainly the developments of the last six weeks, with the spectacular revelations of Soviet progress in the missile and satellite fields, demand revision of any move that would materially reduce either basic research or research and development on military weapons."

Senator Homer Capehart (*R.Ind.*) said, upon his recent return from abroad: "In Russia, the scientists and technicians have been made the heroes of Communist society. They pick their brains out and utilize them. In the U.S., on the other hand, there is this tendency not to cooperate and, in some cases, to beat their brains out. What I want to sell is that this attitude of non-cooperation must change. We must pay more attention to scientists and to educating more scientists."

Drastic Program

Senator Mike Mansfield (*D.Mont.*), the majority whip, speaking before the Southwestern District Montana Education Association Convention at Bozeman, Montana on Thursday, October 24, suggests this program:

1) That a Secretary for Research and Development be named with full cabinet status to assume direct control in all fields of outer space.

(*Continued on page* 172)

. . . and a vital need and a big problem for small business

While just about all small industry would like to be "research-minded," the word research has actually come to be anathema to most small businessmen since it carries with it a connotation of extravagance in both time and money—two items of which small business is usually short.

Almost every facet of the question, "How can the small businessman benefit from technical and distribution research?" was examined and discussed at the recent President's Conference on Technical and Distribution Research for the Benefit of Small Business held in Washington, D. C. The broad purpose of the Conference was to formulate a program under which small firms can avail themselves of up-to-date technological and managerial knowledge.

Perhaps the main fact that emerged from the conference was that small industry is between the horns of a dilemma. While both the small and large businessmen present agreed that those companies willing to spend some of their profits for research or technical service or development would greatly enhance their chances for profitable growth, the word research has come to have a bad meaning to small businessmen in general, since for the most part they see few ways that they can really afford it.

This led directly to the question that if small business is going to get research help, who is going to give it? The problem is enormous in its potential. Of the 285,000 manufacturing companies in the United States, 98 per cent have less than 500 employees.

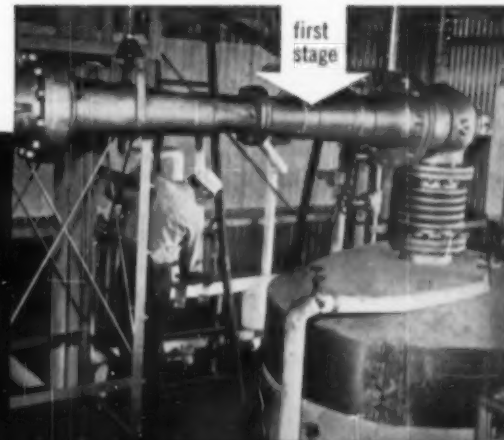
(*Continued on page* 173)

STATEMENT OF R. J. SAULNIER

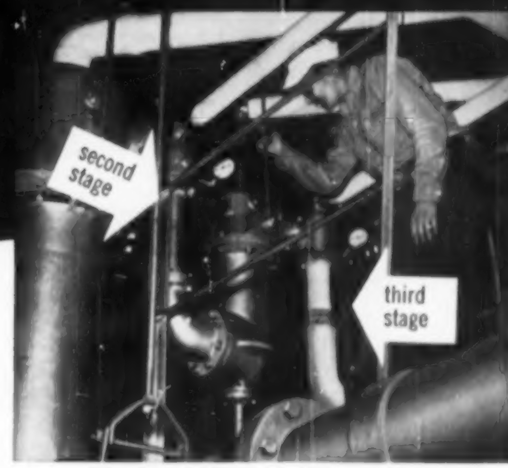
Chairman, President's Council of Economic Advisors

Needless to say, I was delighted at the success of the President's Conference on Technical and Distribution Research For the Benefit of Small Business, as were all those who participated in its planning and conduct. As I observed it, the Conference made the following quite clear: First, those who operate small businesses are intensely interested in the research approach to management problems. They want to know more about research, and how to use it economically. To put it differently, they have a very earnest "How can I do it myself?" attitude toward research. Second, the agencies that serve small business—trade associations, trade papers, schools of business, and others—recognize both an opportunity and a responsibility to help small businesses do research, or to share in the results of research done by others. Third, small businesses want more educational conferences of the sort we held in Washington, but they want them to be held "back home" and want them run by businessmen themselves.

No one could fail to be excited and inspired by the constructive, "Do It Yourself" attitude of these businessmen.



this ELLIOTT three-stage EJECTOR maintains absolute pressure of 0.25 in. Hg in deodorizer

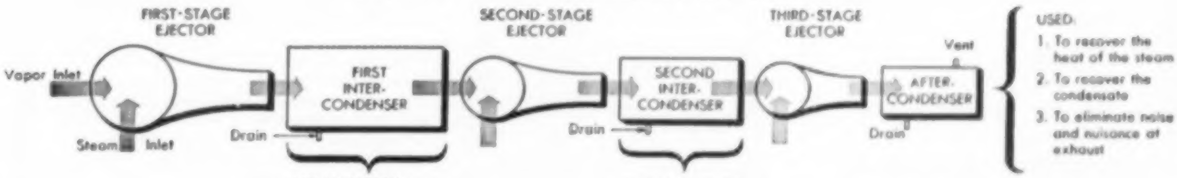


This typical installation serves a continuous lard deodorizer that deaerates, heats, deodorizes and cools in a single vessel. Function of the Elliott three-stage steam jet ejector is to continuously maintain an absolute pressure of 0.25 in. Hg throughout the entire deodorizing vessel.

The first or booster stage seen in the upper photo, compresses stripping steam and discharges to a barometric-type booster condenser, where both motive and entrained steam are condensed. The lower photo shows the second-stage and third-stage ejectors with intercondenser, which compresses noncondensable gases to atmospheric discharge.

The installation illustrates Elliott's wide experience in designing and building multi-stage ejectors for process industry applications. Three-stage ejectors—such as in the schematic hook-up below—are usually applied where an absolute pressure from 1.00 to 0.10 in. Hg is required. Condensers may be either barometric or surface type. For more than 40 years, Elliott steam jet ejectors have proved themselves—again and again—to be a simple and dependable method of maintaining low absolute pressures. Consult with the Elliott ejector specialist at the nearby district office about your requirements, or write Elliott Company, Jeannette, Pennsylvania.

SIMPLIFIED SCHEMATIC of THREE-STAGE EJECTOR



ELLIOTT Company

Ask for ENGINEERING DATA which covers the complete range of Elliott steam jet ejectors including single-stage, special corrosion-resisting, and various multi-stage types.

G7-1

RESEARCH—FRONT PAGE NEWS

(Continued from page 170)

2) That the Administration draw up plans and procedures for a subsidization by the Government of students beginning in the Sophomore year of High School, who show an aptitude in the fields of science and engineering, so that it will be possible for them to finish their education through college and, if especially qualified, into the graduate field. In return such persons on graduation would work for the government for from 5 to 7 years in the armed services or in fields connected with our national security. (As I indicated earlier, the latest figures I have going back 2 years indicate that the Soviet Union in one year graduated 50,000 scientists and engineers; 50,000 sub-scientists and sub-engineers, while the United States in that same year graduated 28,000 scientists and engineers.)

3) That the National Science Foundation should be expanded and given sufficient funds so that it would be possible for it to aid more scientists and engineers and thereby overcome, to a degree, our deficiency in those fields.

4) That joint action in research and development be undertaken by U.S. and European scientists in the fields of thermonuclear energy and outer space. We have no monopoly on scientific brains. Together, we and the scientists of Western Europe can accomplish much more, in our common interests, rather than in a continuation of the hit and miss, uncoordinated activities of the past or the present.

New Association

The missile industry is doing plenty of talking too—but not for publication. At the Carlton Hotel in Washington on October 22, a group of about 70 representatives of contractors and subcontractors engaged in missile and missile c[illegible]nent manufacture unanimously voted to file a certificate of incorporation for the nation's first missile association. Its official name is Association of Missile & Rocket Industries, Inc. While the certificate of incorporation states that "the corporation is not organized for profit," its objective to lobby for legislation favorable to the missile industry seems obvious. Chief complaint against existing conditions was that the "need-to-know" ruling in the security system smothers fresh ideas and new production sources.

If the engineering and scientific societies of this nation want to have a prominent part in the technological resuscitation of America, they will do well to formulate and present a unified program now. If not, the job will be done for them by those well versed in legislative techniques but poorly acquainted with scientific philosophies. One thing seems certain—something big will be done for or to American technology during the coming session of Congress.

(*Continued from page* 170)

They employ 55 per cent of the workers and produce 50 per cent of the value added by manufacturing. Of them, 82 per cent have less than 50 employees. It will require a great deal of research to serve a market this size, and these companies are generally too small to do it themselves.

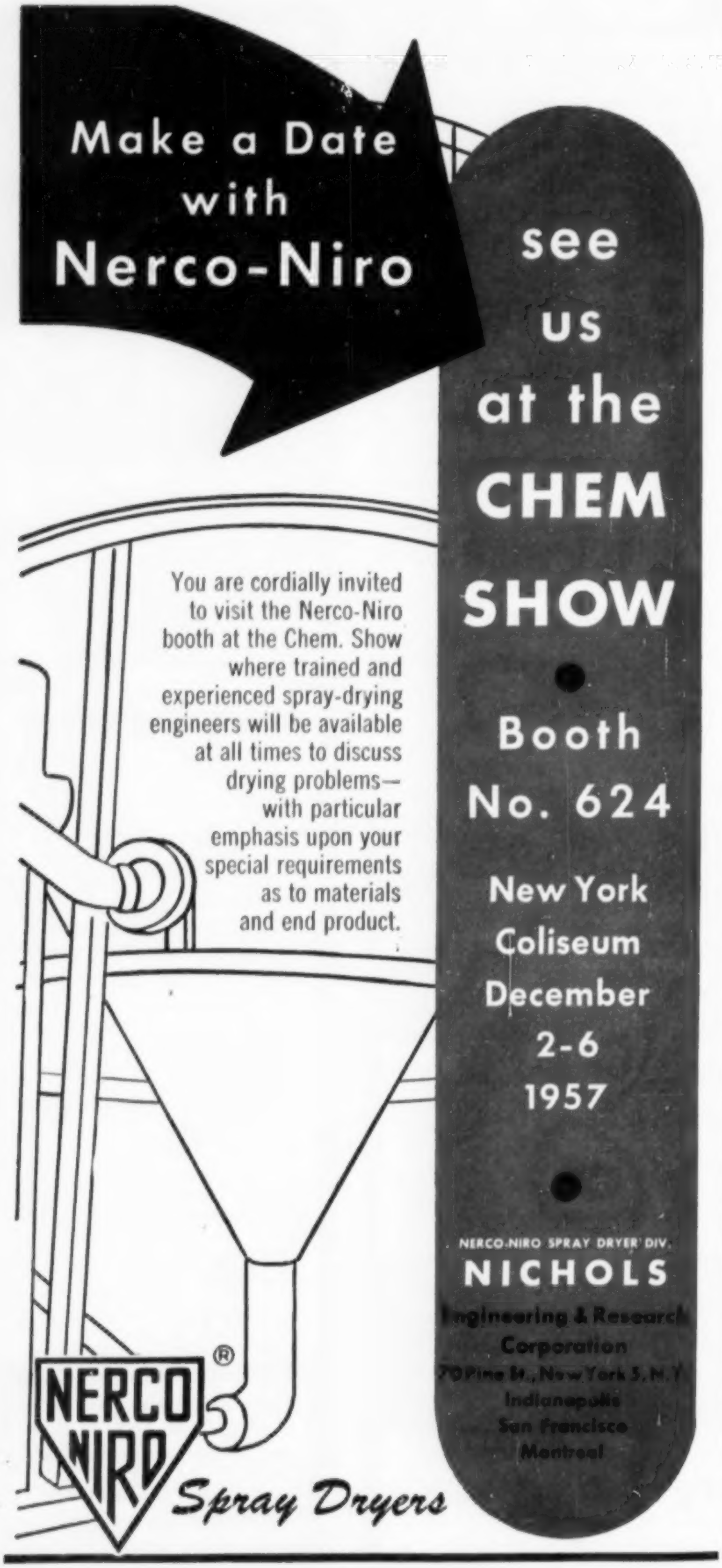
First—Know the Problem

The second major fact to come out of the meeting was that the first thing big business and the Government have to do is learn the real research problems of small industry. While this was acclaimed as one of the best organized, best run, and most satisfactory big conferences ever held in Washington, there was a unanimity of opinion on the need for fewer "inspiring speeches" and more "workshop" sessions. This was undoubtedly because the "experts" who had come to teach small businessmen made the speeches, while the small businessmen themselves did the talking in the workshop sessions. And the small businessmen talked sharply and to the point. The gist of their ideas was that the "experts" need to better understand the problems of small industry and how to analyze its technological and marketing needs before they can hope to administer a cure. Research, *per se*, is not a cure for all the ills of sick business, big or small.

More Meetings

Because small industry represents such a large segment of our economy, it is easy to understand why the Government takes such an interest in promoting a healthy climate in which it can develop. But small business, the meeting showed, is opposed to even the thought of Government guardianship. While there was general agreement that more conferences should be held on local, regional, and national levels, those present were anxious that these further exchanges of ideas be handled by business itself. The formation of a non-profit business association has been suggested as the sponsoring agency.

Executive Director of the Conference C. L. Jewett concluded at a post-meeting interview, "This conference evoked interest . . . far beyond that anticipated by most of us responsible for its organization and operation. I am sure this is not the end—it is just the beginning."



SAFETY INFORMATION

(Continued from page 169)

An enthusiastic group of 47 people from 31 different companies gathered and discussed the question, the writer presiding. The group almost unanimously voted:

(1) their desire to hold another such symposium at the September, 1958 A.I.Ch.E. meeting and yearly thereafter,

(2) that minutes of this meeting should be circulated among the group and to other manufacturers not present,

(3) that it was desirable to set up a communication "round robin" so that critical information could be quickly disseminated and

(4) that an agenda be prepared for the September, 1958 meeting by soliciting items from the group and then circulating a completed agenda prior to the meeting. The majority of those present offered their assistance toward this effort.

The Symposium discussions covered the following subjects:

Ammonia Plant Section:

1. Metal inspection of vessels and piping—intervals and methods.
2. Dumping spent ammonia catalyst—oxidized or unoxidized, methods, precautions.
3. Compressors—tail rod protectors, inspection of rods.
4. Welding and burning—rules and precautions.
5. Nitriding problems—carbon steel, chrome and chrome nickel alloys.
6. Handling anhydrous ammonia—hose, hose couplings, velocity checks, additional pressuring of tank cars and trucks with nitrogen.
7. Safety equipment—masks, suits, showers, deluge devices.

Topics were introduced by Messrs. King (Sohio), Maune (Mississippi River Chemical Company) and Walton (Atlantic Refining).

Air Plant Section:

1. Air intake location—method of determining, use of wind instruments.
2. Removal of particulate matter at air intakes—necessity, degree required, devices.
3. Permissible levels of hydrocarbons—at air inlet, in vaporizer.
4. Permissible level in vaporizer of contaminants—acetylenes, nitrogen oxides, ozone.
5. Analysis by instrumentation—acetylene, total hydrocarbons, MSA analysis, Air Products analyzer, mass spectrometer, gas chromatography.
6. Lubrication—reciprocating compressors, expanders, synthetic lubes, oil removal devices.
7. Silica gel adsorbers and prefilters—specifications of gel, on-stream time, life, minimum regeneration temperature, advantage of prefilters.
8. Frequency and methods of cleanouts—oil, contaminants, dirt.
9. Metal inspection—intervals, methods.
10. Shutdown procedures—holding liquid, equipment for handling drop-out.

11. Desirability of industry sponsored project on catalytic oxidation of air intake.

Topics were introduced by Messrs. Cochrane (Sun), Chubb (Atlantic Refining), Himmelburger (Air Products), Martin (Spencer), Kerry (American Air Liquide), and Holstein (Atlantic Refining). Dr. Karwat (Linde Eisenmachinen) presented a considerable amount of data.

Norton H. Walton
Atlantic Refining Co., Philadelphia, Pa.

INTERNATIONAL CRITICAL TABLES TO BE REVISED; NEW DIRECTOR APPOINTED

Guy Waddington has been appointed Director of the Office of Critical Tables, Division of Chemistry and Chemical Technology, National Research Council, as the program to study and make improvements in the now obsolescent International Critical Tables gets underway.

Since the publication of the International Critical Tables (1926-33) there has been a profound increase in the amount of numerical data of value to research. Many new and important areas are not covered by the Tables at all. While efforts have been made, and are being made, to gather all the new material in one place, the efforts have lacked direction and coordination. To this end the Academy-Research Council established the Office of Critical Tables (1955) which made a study and recommended a full program to revise the tables.

More than thirty American engineering and scientific societies are completing plans for the 4th Nuclear Engineering and Science Conference to be held at the Chicago International Amphitheatre in March, 1958, under A.I.Ch.E. management. Technical sessions (at least 200 papers) will cover all aspects of nonmilitary nuclear technology, ranging from reactor physics to fuel element development and chemical reprocessing. Added attractions at Chicago will be the Atomic Energy Management Conference, sponsored by NICB and AIF, and the annual Atomfair, organized by AIF. The advance program will be available in January, should be requested from any participating society or from Secretary, Engineers Joint Council, 29 West 39th St., New York 18, N. Y. Included in the advance program will be an order form for preprints of papers to be delivered at the Congress. These preprints will be available well in advance of the Congress at nominal cost. □

SALARIES OF ENGINEERING TEACHERS

A new study made by the American Society for Engineering Education using figures originally gathered by EJC reveals:

- **The average engineering teacher in American colleges and universities makes about $550 a month in salary.**
- **80% of engineering teachers earn income outside their salaries, usually from consulting.**
- **Nature of the institution, region, and some other factors affect the teacher's earnings and salary.**

ASEE's new survey showed that the average engineering teacher in colleges and universities in this country earns a salary of $6,634 a year. But he adds consulting and other engineering work to bring his total annual earnings up to $8,862.

He earns more if he teaches in a private school than if he works in a publicly supported school, and he earns more on the Pacific Coast than in any other part of the country.

The figures are for the year 1956, are based on a sample of 4,206 engineering teachers, most of whom were originally surveyed by EJC. As a percentage of all engineering teachers, the 4,206 are about 35% if the definition of engineering teacher used by EJC is considered (EJC used a figure of about 12,000 engineers who are teaching in accredited institutions whether or not these teachers were exclusively engaged in teaching engineering). If ASEE's figures are used, the percentage of teachers responding is 44% since ASEE used only teachers engaged in teaching engineering subjects and came up with a total of about 9,500 in all accredited institutions.

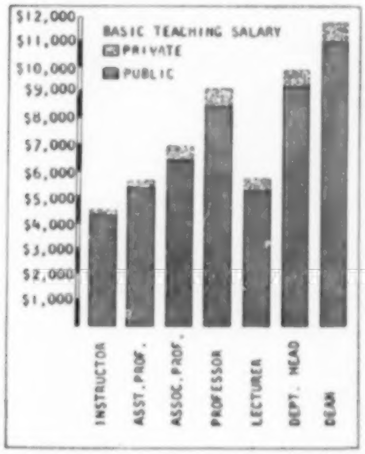
Range by Rank, Outside Income

The survey found that the average salaries for young engineers serving as instructors range from $4,214 in public institutions to $4,374 in private schools. Department heads salaries average $9,117 and $9,893, respectively. (See graph.)

Of the teachers surveyed, 80% reported income beyond their teaching salaries. This income came from various aspects of the direct practice of engineering. Instructors earned an average of over $1,000 annually, and professors earned from $2,346 (public schools) to $4,716 (private schools). On the average, teachers in public institutions had outside earnings of

ENGINEERING TEACHERS

(Continued from previous page)



Annual average teaching salaries of engineering teachers by rank in public and private colleges and universities, 1956.

$2,333, and those in private institutions $3,634. Thus both annual incomes and basic teaching salaries are higher in privately supported institutions than in public institutions, according to ASEE's survey.

Regional Differences

Basic engineering teaching salaries vary somewhat across the nation. Averages in public institutions range from a low of $4,086 in the Mountain States to $6,886 in the Midwest, and in private institutions from a low of $5,133 in the Mountain States to $7,613 on the Pacific Coast. But with the exception of the relatively low-paid Mountain States, there is not much difference in salaries by region.

Total average annual income however, tends to vary more widely, with the Mountain States again low with $7,319, and the Pacific Coast high with $12,500.

Overall Study

The salary survey is only a part of the ASEE project which is being conducted under a grant from National Science Foundation and some smaller grants from private institutions. Main goal of the study is how to increase the supply of competent teachers for engineering colleges, and the Committee involved is concerned with ways and means of making careers in engineering education competitive in terms of total rewards and satisfactions.

The figures in this survey are for 1956 and the Committee states that there is already growing evidence that salaries are improving in colleges throughout the country.

FUTURE MEETINGS

HOUSTON, TEXAS

November 20 and 21, 1957. Shamrock Hilton Hotel. Joint Meeting of Commercial Chemical Development Association and Chemical Market Research Association. Theme of meeting will be "The Gulf Coast Chemical Industry in 1965—a Forecast."

CHICAGO, ILL.

December 8-11, 1957. Conrad Hilton Hotel. Annual Meeting, A.I.Ch.E. The complete program was published in the October issue. For last-minute developments and pictures of those presenting papers at the meeting, see page 162.

1958 MEETINGS

• Chicago, Ill., March 17-21, 1958.
1958 Nuclear Congress. Managed by A.I.Ch.E. Coordinated by E.J.C. Will include: 4th Nuclear Engineering and Science Conference, 4th International Atomic Exposition, 6th Atomic Energy in Industry Conference, 6th Hot Laboratories and Equipment Conference, and the American Power Conference.

• Montreal, Canada, April 20-23, 1958. Sheraton-Royal Hotel. Joint A.I.Ch.E.-C.I.C. Conference. A.I.Ch.E. CHAIRMAN: Kenneth Beatty, North Carolina State College, Raleigh, N. C. CO-CHAIRMAN: W. H. Gauvin, McGill University, Montreal. **Chemical Engineering Aspects of Heavy Water Power Reactors**—CHAIRMAN: Donald Stuart, Evaluation Section, Civilian Power Reactors Branch, A.E.C., Washington 25, D. C. CO-CHAIRMAN: W. M. Campbell, Canadian A.E.C. **Chemical Engineering Methods in Mineral Processing**—CHAIRMAN: L. A. Roe, Int. Minerals and Chemical Corp., Chicago 6, Ill., CO-CHAIRMAN—F. A. Forward, University of British Columbia, Department of Mining & Metallurgy, Vancouver 8, B. C. **Fluid Mechanics**—CHAIRMAN: S. G. Mason, Dept. of Chemistry, McGill Univ., Montreal, P. Q. **Noise in the Chemical Industry**—CHAIRMAN: G. Thiessen, Physics Division, National Research Council, Ottawa, Ontario. **Chemical Engineering Technology in the Pulp and Paper Industry**—CHAIRMAN: L. R. Thiesmayer, Pulp and Paper Research Institute of Canada, 3420 Univ. St., Montreal, P. Q. **Future Sources of Energy**—CHAIRMAN: J. W. Hodgins, Director of Engineering Studies, Hamilton College, McMaster Univ., Hamilton, Ontario. **Modern Chemical Plant Construction Techniques**—CHAIRMAN: S. A. Guerrieri, Lummus Co., 385 Madison Ave., New York 17, N. Y. **High Temperature Materials for Jets and Rockets**—CHAIRMAN: Charles Marsel, New York University, New York, N. Y. **Statistics in Chemical Engineering**—CHAIRMAN: J. C. Whitwell, Princeton University, Princeton, N. J. **General Papers** (2 sessions)—CANADIAN CHAIRMAN (pro tem): W. H. Gauvin, Dept. of Chemical Engineering, McGill Univ., Montreal, P. Q.; AMERICAN CHAIRMAN: H. Donnelly, Wayne University, Detroit, Mich. Special panel discussion (Sunday afternoon, April 20, 1958)—**Chemical Engineering Education in the United States and in Canada**—MODERATOR: W. G. Whitman, Dept. of Chemical Engineering, M.I.T., Cambridge, Mass.

• Namur, Belgium, June 10-13, 1958. **First International Congress on Vacuum Techniques**, sponsored by Commissariat General of the Belgian Government with the Brussels 1958 International and Universal Exhibition. Further information from Professor E. Thomas, c/o CSN/ERM, 30, Avenue de la Renaissance, Brussels 4, Belgium.

• Berkeley, California, June 19-21, 1958. Dwinelle Hall, University of California. **1958**

Heat Transfer and Fluid Mechanics Institute. Sponsored by Calif. Institute of Tech., Stanford Univ., University of Calif., Univ. of Santa Clara, Univ. of Southern Calif., A.I.Ch.E., Amer. Rocket Society, A.S.M.E., Amer. Society of Refrigerating Engineers, Institute of Aeronautical Sciences, Society of Automotive Engineers. Papers invited on fundamental aspects of heat transfer and fluid mechanics. Titles and abstracts to be submitted by November 1, 1957. General Chairman: A. K. Oppenheim, Mechanical Engineering, Univ. of Calif., Berkely, Calif.

- Philadelphia, Pa. June 22-27, 1958. **Bellevue-Stratford Hotel. A.I.Ch.E. Fiftieth Anniversary Meeting. CHAIRMAN: Roy** Kinckiner, DuPont, Wilmington, Del. **Theme for program is: A Look to the Future.** All symposia and papers are being planned in accordance with this theme. **Fluid Mechanics, Heat and Mass Transfer**—Organizer: C. R. Wilke. **What Does the Future Hold?**—Organizer: William J. Borns, Socony Vacuum Oil Co., Paulsboro, N. J.

- August 18-21, 1958. **A.I.Ch.E.-A.S.M.E. Heat Transfer Conference. CHAIRMAN: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.**

- Salt Lake City, Utah, Sept. 21-24, 1958. **A.I.Ch.E. Nat'l. Meeting.** CHAIRMAN: E. B. Christiansen, Dept. of Chem Eng., Bldg. 437, Univ. of Utah, Salt Lake City. **Air Pollution**—CHAIRMAN: W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California. **What's New in Liquid Metals Technology—CHAIRMAN: Marshall Sittig, American Lithium Institute,** Inc., P.O. Box 549, Princeton, N. J. **Crystallization**—ORGANIZER: C. S. Grove, Jr., Director of Engineering, Syracuse Univ. Research Institute, Syracuse 10, N. Y. **Foams and Froths**—ORGANIZER: J. Louis York, Dept. of Chemical Engineering, Univ. of Mich., Ann Arbor, Mich. **Ethylene**—ORGANIZER: Hermann C. Schutt, 201 Devonshire Street, Boston, Mass.

- Cincinnati, Ohio, December 7-10, 1958. **Netherland Plaza Hotel. A.I.Ch.E. Annual Meeting. TECHNICAL PROGRAM CHAIRMAN: A. C. Brown,** Emery Industries, Inc., June & Long Streets, Ivorydale, Ohio. **Liquid Pollution**—C. Fred Gurnham, Dept. of Chem. Eng., Michigan State U., East Lansing, Michigan. **Distillation**—CHAIRMAN: W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. **High-Speed and Time-Lapse Photography in Chemical Engineering**—CHAIRMAN: J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. **Kinetics & Rate Processes**—CHAIRMAN: H. E. Hoelscher, Dept. of Chem. Eng., John Hopkins Univ., Baltimore 18, Md. **New Approaches for Commercial Chemical Development**—CHAIRMAN: H. E. Wessel, Monsanto Chemical Co., 1700 South Second Street, St. Louis, Mo. **Reprocessing of Fluid Reactor Fuels**—CHAIRMAN: O. E. Dwyer, Chemical Engineering Division, Brookhaven National Laboratory, Upton, L. I., N. Y. **The Application of Computers to Heat and Mass Transfer Problems**—CHAIRMAN: J. M. Smith, Northwestern Univ., Evanston, Ill. **Low Temperature Processing**—CHAIRMAN: C. McKinley, Air Products, Inc., Allentown, Pa. **Applied Heat Transfer**—CHAIRMAN: Not yet appointed. **Scale-up from Pilot Plant to Plant**—CHAIRMAN: D. B. Coghlan, Foote Research and Development Laboratories, Berwyn, Pa. CO-CHAIRMAN: R. A. Schulze, DuPont, Chambers Works, Jackson Labs., Penns Grove, N. J.

(*Continued on page* 180)

FUTURE MEETINGS *(Continued from page 179)*

Conrad Hilton Hotel (arrow, left) is meeting headquarters for the December 8-11 Annual Meeting of A.I.Ch.E. See late news developments and authors' pix on page 162.

1959 MEETINGS

- Kansas City, Mo., May 10-13, 1959. TECHNICAL PROGRAM CHAIRMAN: Fred Kurata, Chemical Engineering Dept., Univ. of Kansas, Lawrence, Kansas.
- San Francisco, Calif., December, 1959. TECHNICAL PROGRAM CHAIRMAN: C. R. Wilke, Division of Chemical Engineering, Univ. of California, Berkeley, Calif.

S.O.S.

The Roundtable Discussions held at recent A.I.Ch.E. National Meetings have enjoyed such wide popularity that the Program Committee has decided to emphasize this type of get-together at other meetings in the near future. Suggestions for topics are needed badly and will be welcomed with open arms. Ideas should be sent to E. R. Smoley, Asst. Program Chairman, A.I.Ch.E., Lummus Co., 385 Madison Ave., New York 17, N. Y.

UNSCHEDULED SYMPOSIA

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

- **Centrifugation:** James O. Maloney, Dept. of Chem. Eng., U. of Kansas, Lawrence, Kans. The theory and quantitative aspects of centrifugation.
- **Size Reduction:** Edgar L. Piret, Chem. Eng. Dept., U. of Minnesota, Minneapolis 14, Minn.

- **Filtration & Centrifugation:** Horace Hinds, Jr., Basic Vegetable Prod. Co., Vacaville, Calif.
- **Chemical Engineering Process Dynamics as They Affect Automatic Control:** David M. Boyd, 315 Ridge Ave., Clarendon Hills, Ill.
- **Dry Classification of Solids:** D. W. Oakley, Metal & Thermit Corp., Carteret, N. J.
- **Education of Chemical Engineers:** F. M. Tiller, Dean of Eng., University of Houston, Cullen Blvd., Houston 4, Texas.
- **The Threatened Imbalance Between Chlorine and Alkali in American Chemical Industry:** Zola G. Deutsch, Deutsch & Loonam, 70 E. 45th St., New York City 17.
- **Start-Up of New Chemical Plants:** M. L. Nadler, Du Pont, Wilmington, Del.
- **Computers in Optimum Design of Process Equipment:** Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.
- **Financing for the Chemical Industry:** Bernard Stott, First National City Bank of New York City, New York, N. Y.
- **Chemical Engineers in Chemical Industry Management:** T. P. Forbath, American Cyanamid Co., 488 Madison Ave., New York, N. Y.
- **Training on the Job for Industry:** John Happel, Dept. of Chem. Eng., N. Y. University, University Heights, New York 53, N. Y.
- **Alternate Energy Sources:** Henry F. Nolting, Standard Oil Co., Whiting, Ind.
- **Thermodynamics of Phase-Equilibria:** E. H. Amick, Dept. of Chemical Engineering, Columbia Univ., N. Y.
- **Properties of Liquids:** S. E. Isakoff, Engineering Research Laboratory, Du Pont, Wilmington, Del.
- **Preparation of Catalytic Cracking Charge Stocks and Quality Criteria Therefor:** Wheaton W. Kraft, Lummus Co., 385 Madison Ave., New York 17, N. Y.

AUTHOR INFORMATION

Submitting Papers

Procedure to be followed is, in brief:

1—Obtain four copies of "Proposal to present a paper before the A.I.Ch.E.," plus one copy of "Guide to Authors" from Secretary A.I.Ch.E., 25 West 45th St., New York 36 N. Y.

2—Send one copy of completed form to Technical Program Chairman for meeting selected from above list.

3—Send another copy to Mr. E. R. Smoley, The Lummus Co., 385 Madison Ave., New York 17, N. Y. (Asst. Program Comm. chairman).

4—Send third copy to Editor, Chemical Engineering Progress, 25 West 45th St., New York 36, N. Y. Paper will automatically be considered for possible publication in A.I.Ch.E. Journal.

5—If desired to present paper in a selected symposium, send fourth copy to chairman of the symposium.

6—Prepare five copies of manuscript. Send one copy each to Symposium chairman, Technical Program chairman, or both copies to latter if no symposium is involved. Other three copies should be sent to Editor, C.E.P. Presentation at meeting offers no guarantee of acceptance for publication.

DEADLINES

Papers intended for presentation at a meeting should be submitted not later than four months before the meeting.

A.I.Ch.E. News of the Field FROM LOCAL SECTIONS

TRAINING RUSSIAN ENGINEERS

The Soviet engineer is a well-trained, specially-selected technologist with a preferential position in his country. The Soviet is turning out a lot of them, uses them to gain influence abroad and to make the scientific advances the USSR wants for propaganda purposes in the cold war.

The September meeting of the **El Dorado Section** (*G. D. Rucker*) heard a first-hand report from D. M. Boyd, Jr., on the training and position of the Soviet engineer. Boyd went to the USSR in the summer of 1956.

In the Soviet Union, engineering graduates are paid about five times as much as truck drivers, and the president of an engineering college is on the same level as the president of a utility company.

Each year some 80,000 engineers are produced, according to Boyd, as compared with 23,000 a year in the United States. Whether or not the definition of "engineer" is the same in both countries is not certain.

Prospective engineering students are given an examination which includes aptitude tests, and the state then picks the ones who will be sent to engineering school. The state starts about five times the number it intends to graduate and culls them down as the education progresses, much as happens in the U. S. but on a less voluntary and haphazard basis. Students are paid to go to school just as if they were working on a job.

The Soviet Government, according to Boyd, seems to recognize the danger of educating the people too much and tries to overcome this by giving the educated special preferential treatment.

One of the Soviet's ways of using their engineers is to send them abroad to aid the people of foreign countries and thus gain a foothold in such countries.

Some problems of the Soviet engineer are those of estate and family position. The Soviet engineer has no personal estate. If he should die or fall from favor, his family will be left with nothing, according to Boyd, and he cannot guarantee his children an education—that is all based on the competitive examinations.

As an example of the lead the Soviet has over us in many engineering fields, Boyd cited the process control engineer, a field somewhere between the chemical engineer and the electronic engineer. We graduate some 200 process control engineers a year. The Soviet graduates about 5,000 a year.

FUELS NEW AND OLD, NUCLEAR ENGINEERING, RESEARCH, ARE AMONG LOCAL SECTION SUBJECTS

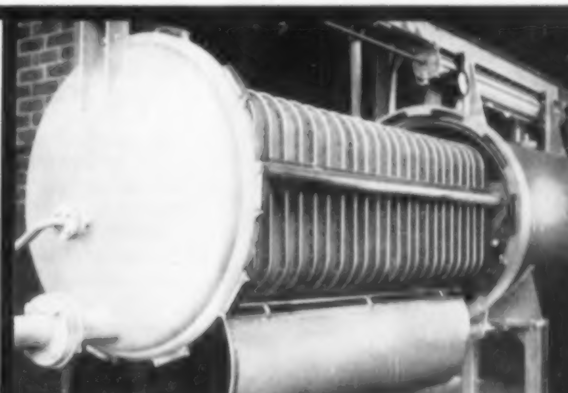
The new high-energy fuels took the spotlight at the October meeting of the **Pittsburgh Section** (*R. Frumerman*) as D. K. Eads, evaluation engineer in Callery Chemical's Research and Development Division, described the rapid development of the boron fuels and chemicals. It has been less than ten years since the first contract was made to produce several pounds of diborane for the Office of Naval Research to the present program involving the construction of multimillion dollar plants by Callery and Olin Mathieson to produce the fuels. From this program, in addition to fuels, have come many new compounds—powerful reducing agents, polymerization catalysts, fire extinguishing agents, and fungicides.

Turning to the entire field of energy sources, B. F. Dodge told the September meeting of the **New Haven Section** (*H. Borsvold*) that although there are abundant fossil fuels, they will probably be near exhaustion before the year 2050. Fossil fuels are prime examples of non-renewable fuels, and there is no doubt that they will someday run out. Several experiments with renewable sources of energy were pointed out by Dodge: a 5,000-kw. wind-powered generator; a French development to use the temperature differences of the sea with a heat pump; the use of tides; and a sun house in Massachusetts heated by solar energy. In Dodge's view, future space-heating requirements will be met primarily with solar energy while industrial power will be derived primarily from nuclear fuels.

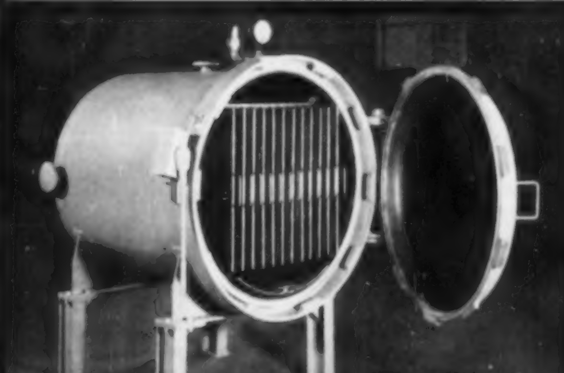
Still in the area of fuels, P. F. Swanson, M. W. Kellogg Co., predicted at the September meeting of the **New York Section** that the intensity of oil refining will be stepped up sharply in the U. S. during the next few years. Probably the greatest boost in the oil processing industries will come from expansion outside the U. S., and in the next ten years refining capacity abroad will double. According to studies made by Kellogg, the total free world expansion will be around 10 million barrels a day, which

(*Continued on page* 184)

when is a filter truly a batch filter?



MODEL H PROCESS FILTER WITH BATCH RECOVERY LEAF FEATURE
Sizes: 90 to 1000 sq. ft. (units up to 3500 sq. ft. custom engineered.)



MODEL HB PROCESS BATCH RECOVERY FILTER
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when it filters a complete preparation down to the last drop!

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THERE'S NO WASTE — NO NEED FOR STORAGE! Featuring separately piped recovery leaves, PF Batch Filters are outfitted to handle unfiltered residue remaining in the tank at the end of the regular filtration cycle. The residue is filtered via blow-down rapidly down to practically the last drop in approximately the same time it would take to blow it back to a storage area . . . *and with less loss of residue.*

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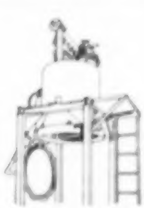
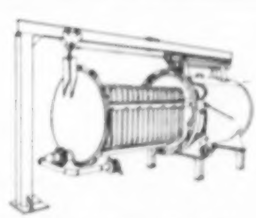


VERTICAL BATCH FILTERS



HORIZONTAL LEAF FILTERS

CARTRIDGE FILTERS

A.I.Ch.E. News of the Field

FROM LOCAL SECTIONS

(Continued from page 182)

will require an investment on the order of $10 billion. Regarding automation in the oil refinery, Swanson does not expect that the "dream of controlling a process unit from a pushbutton in a downtown office" will be realized—there are too many technical and human difficulties involved. He pointed out that today the oil refining process operations are already controlled to a high degree, and additional facilities for data logging and analyzing streams are being installed and watched with great interest.

Nuclear Engineering

Discussing some problems in nuclear engineering before the October meeting of the **Philadelphia-Wilmington Section** (*T. S. Mertes*), C. F. Bonilla identified three phases of nuclear engineering that were of interest to the chemical engineer: 1) nuclear reactor physics, which deals specifically with the nuclear phenomena (such problems as neutron blanketing, moderators, and other control devices for regulating the fission process are included in this field); 2) nuclear reactor engineering, which consists of those chemical engineering problems (such as heat transfer, fluid flow, etc.) which are basic chemical engineering operations and have no special relation to nuclear phenomena; and 3)

(Continued on next page)

MURPHREE AT NEW JERSEY

E. V. Murphree, president of Esso Research and Engineering Co. and recently on duty with the Government as Special Assistant to the Secretary of Defense for Guided Missiles, here explains some of the intricacies of the guided missile program to L. J. Heney, J. W. Axelson (chmn.), and D. M. Calkins of the New Jersey Section (*R. J. Boyle*) at the section's September meeting. Murphree explained the four types of missiles: 1) surface to air; 2) air to air; 3) air to surface; and 4) surface to surface. In explaining the specific end-use for each type, Murphree showed why the armed forces have developed so many missiles. Four major problems still face the missile field: 1) better missile guidance; 2) more reliability; 3) better fuels and propellants; and 4) better missile detection.

nuclear process engineering. In this phase the chemical engineer is interested not only in the reactor but in the whole process. He is interested in the economy of the operation and so selects his fuel, working fluid, and type of reactor.

F. T. Barr, Esso Research and Engineering, continued the discussion of nuclear energy in his talk to the October meeting of the **New Jersey Section** (*R. J. Boyle*) but concentrated more on the applications of nuclear energy to industry. Barr pointed out that while much of the present work in the atomic field is sponsored or aided to a large extent by the Government, industry is steadily contributing an ever increasing amount. Much work has already been done in agriculture, manufacturing, medicine, and chemical reactions. Radioisotopes alone offer a promising field for the future.

Uranium mining, while not strictly a chemical engineering operation, is so vital to both the nuclear industry and the chemical processing branch of the nuclear industry, that two sections went into a discussion of it recently. At the September meeting of the **Knoxville-Oak Ridge Section** (*R. W. Horton*), the Uranium Industry in South Africa was explained by H. B. Malan, Stellenbosch University, City of Stellenbosch, South Africa. The major source of ore in South Africa is tailings from the widespread gold mining operations. Conventional processes are used to produce about 5,000 tons a year (U_3O_8 equivalent) from this low grade ore source.

At the **Oklahoma Section** (*E. R. Beck*) Uranium Mining and Processing was analyzed by T. M. Hipp, Phillips Petroleum, during the section's September meeting. The importance of uranium, Hipp said, is shown by the simple fact that more lineal feet of core holes have been drilled for uranium in the past five years than for oil in the past 20 years. At Phillips' new Ambrosia Lake, New Mexico, mill, a carbonate leach process for recovery of the uranium will be used. Since each ton of ore contains only some four to five pounds of concentrate, close process and quality control measures will be used to insure maximum efficiency. From an energy point of view, the new Phillips mill will produce the equivalent of 255,000 barrels of refinery fuel a day.

Research Problems

The Problems of the Experimenter held the floor at the September meeting of the **East Tennessee Section**

(*Continued on page 186*)

News of the Field FROM LOCAL SECTIONS

(Continued from page 184)

(*A. J. Peacock, Jr.*). Speaker W. J. Youden, National Bureau of Standards, pointed out that the four main problems that beset the experimenter are: 1) keeping the experimental error small; 2) obtaining a valid or proper estimate of the experimental error; 3) eliminating or avoiding systematic errors; and 4) keeping a proper check on the equipment. In determining the experimental error, the memory effect and time element must be considered. Repetition is of two kinds: simple and concealed. Repetition, however, is sometimes misleading and one should be cautious of the experimental error obtained where the only measure is repetition. In some cases, proper programming of an experiment can result in direct or concealed repetition, elimination of the systematic errors, and can provide an equipment check while actually doing the experimental work.

Speaking on one of chemical engineering's most controversial subjects, C. W. Legget, R. M. Parsons Co., told the **Southern California Section** (*L. N. Miller*) in September that bubble cap trays will play a less important part in the future due to post-war developments in fractionating trays. Plate efficiency has little to do with this decreasing use. It results, according to Leggett, from the higher cost of bubble trays and equal or higher capacity of available fractionating devices. Pointing out that the multitude of tray types on the market is really only a small fraction of the trays presently devised, Leggett listed the factors for deciding on a given tray. They are: cost, capacity, flexibility, efficiency, proven performance, and pressure drop. In his opinion, Leggett maintained, extended research might tend to level out the inequalities in capacity and efficiency among the better trays of today until they all approached a common limitation based on non-reducible entrainment. More research on pressure drop, downcomer, and weir design (including froth decay and entrainment) could increase the capacity of tomorrow's columns by at least 50 per cent. Leggett stated that there is a strong trend toward the use of sieve trays, flexitrays, and float valve trays, and he expects the trend to continue.

NUCLEAR ENGINEERING DIVISION SELECTS NEW OFFICER NOMINEES

A.I.Ch.E.'s Nuclear Engineering Division Nominating Committee has just announced the nominees for office in this active division.

The accelerating importance of nuclear engineering is underscored by the caliber of the new candidates for offices in the A.I.Ch.E.'s Nuclear Engineering Division. This fast-growing division has already made much progress in working with the many facets of the problems of the chemical engineer in the field of nuclear engineering. With the new officers, the activities of the division will continue to grow.

The following slate has been submitted by the nominating committee: for Chairman, W. K. Davis, Division of Reactor Development, AEC; Vice-Chairman, J. W. Clegg of Battelle Memorial Institute, and E. B. Gunyou, Nuclear Products Section, Koppers; Secretary-Treasurer, G. H. Beyer, Dept. of Chem. Engineering, Univ. of Missouri, and C. E. Dryden, Dept. Chem. Engineering, Ohio State Univ.; Executive Committee Members, C. F. Bonilla, Dept. Chem. Engineering, Columbia Univ., M. Smutz, Dept. Chem. Engineering, Iowa State College, and C. E. Stevenson, Atomic Energy Division, Phillips Petroleum.


Davis


Clegg


Gunyou


Beyer


Dryden


Bonilla


Smutz


Stevenson

A.I.Ch.E. DIRECTORY

The 1957 directory of members of the American Institute of Chemical Engineers is now available. Members, Associate Members, and Affiliates may obtain a copy by writing to the Office of the Secretary, 25 West 45 Street, New York 36, New York.

CANDIDATES FOR MEMBERSHIP IN A.I.Ch.E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before December 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

• Benny, Arthur L., *Trona, Calif.* Bevermann, J. Fred, *Wilmington, Del.* Bierbower, Robert G., *Claymont, Del.* Birmingham, M. E., *So. Charleston, W. Va.* Burns, William A., *Richland, Washington.*

• Campagnolo, Joseph F., *Westwood, N. J.* Cierkowski, E. J., *Wilmington, Del.*

• Donath, E.E., *Pittsburgh, Pa.* Dye, Cloyde G., *Barberton, Ohio.*

• Ellis, William A., *Scotch Plains, N. J.*

• Gifford, Maurice J., *Freeland, Mich.* Goodman, Gerald M., *Whiting, Ind.*

• Hart, Nelson R., *Pasadena, Texas.* Hobson, Merk, *Lincoln, Nebraska.* Howell, H. J., *Dallas, Texas.* Hutchinson, R. Earl, *South Gate, Calif.*

• Istas, L. J., *Portland, Oregon.*

• Kosey, Anthony P., *Newark, Del.*

• Landrigan, Richard B., *Columbus, Ohio.*

• Martens, Willie P., *Deer Park, Texas.* Mathis, Howard M., *Alhambra, Calif.* McCurdy, Hubert A., *Dalton, Illinois.* Mutaffis, Thomas Dinitrois, *North Plainfield, N. J.*

• Parish, Clyde E., *Houston, Texas.*

• Rinaldo, Peter M., *Lexington, Mass.* Robb, Walter L., *Schenectady, N. Y.* Ryan, Clarence W., *Wood River, Illinois.*

• Scott, Arthur K., *Linden, N.J.* Sullenberger, David E., *Shreveport, La.*

• Warner, Eric S., *San Francisco, Calif.* Williams, Jack Roger, *Bartlesville, Okla.* Wolfe, Russell M., *Lynchburg, Va.*

Associate Member

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• Carter, A. Leo, *Winchester, Ohio.* Ceccon, Clario, *White Plains, N. Y.* Cerney, Joseph, III, *Oxford, Mississippi.* Chambers, John L., *Baton Rouge, La.* Chertok, Benson, *Laconia, N. H.* Christie, David E., *Moorestown. N. J.* Church, John Phillips, *Logan, Ohio.* Clement, David E., *Pittsburgh, Pa.* Cohen, Allan R., *Cincinnati, Ohio.* Comisky, William T., *Port Neches, Texas.* Coppock, Harold Leroy, *Enid, Okla.* Constantini, Louis, *Bronx, N. Y.* Cowper, Bayard T., *Atlanta, Ga.* Cox, Roger W., *Worthington, Ohio.* Cronau, Randolph C., *E. McKeesport, Pa.* Curry, Morris R., *Greensboro, N. C.*

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• Haaland, Jerry R. *Portland, Oregon.* Hagney, Dennis J., *Indiar [illegible]a.* Hall, Wayne E., *Chicago, Illinois.* H[illegible]son, Edward B.,

(Continued on page 190)

CANDIDATES FOR A.I.Ch.E. MEMBERSHIP

(Continued from page 189)

Ephrata, Pa. Hanson, Kenneth L., *New Haven, Conn.* Hazlebeck, David E., *Portsmouth, Ohio.* Heller, Garson F., Jr., *Scarsdale, N. Y.* Helms, Jon D., *Toledo, Ohio.* Hering, Burton, *Bronx, N. Y.* Hersch, Martin, *Cleveland Heights, Ohio.* Heyne, B. C., *Pittsburg, Calif.* Hirshfeld, David S., *Baltimore, Md.* Holton, James Robert, *Atlanta, Ga.* Horn, John A., *Borger, Texas.* Hoyt, John, Jr., *Mt. Vernon, Ohio.* Hron, Robert John, *Brooklyn, N. Y.* Hvizdos, John Albert, *Duquesne, Pa.* Hylsky, Edward, *Waco, Texas.* Hymer, Alvin E., II, *Bartlesville, Okla.*

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• Unger, Robert, *Tarzana, Calif.*

• Van Saye, Charles C., *Media, Pa.* Veir, Byron B., *Pt. Pleasant, W. Va.* Vetter, Frank W., *Columbus, Ohio.* Viglianco, Carl Michael, *Houston, Texas.*

• Wagner, Oren H., *Taylorsville, N. C.* Wall, Oscar Edward, Jr., *Newton, Mississippi.* Warchol, Richard J., *Wakefield, Mass.* Ward, Newton E., Jr., *San Francisco, Calif.* Warnick, Edwin L., *Fostoria, Ohio.* Weaver, Richard H., *New Orleans, La.* Webster, Thelton A., *Nashville, Tennessee.* Weed, Ronald D., *New Plymouth, Idaho.* Weidner, Thomas H., *Allentown, Pa.* White, Gerald A., *Williston Park, L. I. N. Y.* White, Thomas R., *Cincinnati, Ohio.* Whitesell, Gordon L., *Pensacola, Fla.* Whitmore, William L., *La Porte, Texas.* Wildman, George T., *Grasmere, N. H.* Williams, David H., Jr., *Bishop, Texas.* Willis, Gordon M., *Covington, Ky.* Winkle, Thomas R., *Columbus,*

(Continued on page 206)

CEP CAMERA

LOX AND NH_3 PLANT SAFETY

is off to a new start with formation of a plant operators group affiliated with A.I.Ch.E. (and cooperating with the engineering-design firms) which took place at recent Baltimore National Meeting. Decision to organize was made at a business meeting in between day-and-a-half discussion sessions, one of which is shown below. Principal organizers of operators group were Norton Walton, right, Atlantic Refining, and Harold Maune, center, Mississippi River Chemical Co., shown talking with G. S. Cochrane, Sun Oil Co., one of the participants in the session. Further details on page 169.

TESTING UNIT

newly installed by J. H. Day Co. Div., Cincinnati, Ohio for customer service having to do with applications of dry material processing equipment. Shown in section of lab are conveying, sifting, and mixing items.

INFLATED WAREHOUSE

erected in one hour by a crew of three men is made of vinyl coated nylon fabric. Building uses low pressure air for support, which is conditioned to heat or cool structure. Costing about $1/sq.ft., most popular size is 40 × 80, 20 ft. high, which provides 40,000 cu.ft. of storage space. *(Courtesy Hoosier Tarpaulin & Canvas Goods Co., Indianapolis, Ind.)*

"C.P." COKE

having a sulfur content of less than 0.25 per cent is being produced as a principal product of a new refinery at Gilsonite, Colorado. Seven hundred tons/day of naturally-occurring gilsonite, a solidified hydrocarbon, is pumped in slurry form through a unique pipeline over a mountain range to the refinery. Two hundred seventy-five tons/day of coke are produced, shipped to the Pacific Northwest for aluminum industry electrodes. Shown is Lee P. Morris, American Gilsonite refinery superintendent.

ULTRA-PURE NIOBIUM

is produced by Westinghouse using "cage-zone melting." Purification is accomplished by keeping the metal molten at 4,400° F. in a high vacuum—first application of such a process. Niobium at 2,000° F. is said to be several times stronger than the best available nickel- and cobalt-base metals.

BACK FROM U.S.S.R.

is chemical engineering educator Edgar L. Piret, who toured major teaching facilities during his visit to the Soviet Union to study the processing of peat. Piret will report and show pictures taken on his trip at the Chicago Annual Meeting (see page 162).

people

MURRAY PROFESSIONAL ACHIEVEMENT WINNER

"I hope and believe that the very fact that Sputnik now circles overhead will stimulate our own government's defense developments and at the same time encourage more students to embrace science as a career." So said R. Lindley Murray, board chairman of Hooker Electrochemical Co., speaking at a recent award dinner in Niagara Falls where he received the Sixth Annual Professional Achievement Award of the Western New York Section, A.I.Ch.E. Continuing his remarks on Russia's earth satellite, Murray emphasized that "our chemical industry will play a vital part in the development and production of components of the high energy fuels required for propulsion of rockets and missiles."

Murray was one of the founders of the Western New York Section and served for five years as a national director of the A.I.Ch.E.

R. Lindley Murray (left) receives Professional Achievement Award of the Western New York Section, A.I.Ch.E. David F. Altimier (right), chairman of the Section, made the presentation.

John Happel, professor and chairman of the Department of Chemical Engineering, New York University, will lecture this fall at the Royal Institute of Technology, Stockholm, Sweden, on the subject "Slow Viscous Motion Relative to Suspensions of Spherical Particles." Happel will also visit various German technical schools under the auspices of the United States Information Service.

Happel

Edgar C. Bain, assistant executive vice-president for operation, United States Steel Corp., retires after nearly thirty years of service with the corporation.

Dow Chemical transfers **Robert W. Hawley**, head of chemical engineering development in the Technical Section of their Rocky Flats, Denver, plant to the corporation's Economic Evaluation Department, Midland, Mich. In making the transfer, Hawley was forced to resign his post as 1957-1958 chairman of the Rocky Mountain Section, A.I.Ch.E.

Churchill

Stuart W. Churchill has been promoted from associate professor to professor of chemical engineering at the University of Michigan.

B. F. Goodrich Chemical Co. announces appointment of **Charles L. Woods, Jr.**, as plant engineer for its Louisville, Ky., plant. Woods succeeds **Russell C. Grover**, recently named plant engineer at the company's new Henry, Ill., plant, now under construction.

William L. Bolles becomes a manager in the Engineering Department of Monsanto Chemical's Lion Oil Co. Division at El Dorado, Ark.

Frederick G. Sawyer appointed vice-president of Jacobs Engineering Co., Pasadena, Calif. Sawyer was formerly with Ralph M. Parsons Co., Los Angeles, in chemical business development and as manager of public relations and advertising.

Sawyer

Charles B. Cooper, presently plant manager of B. F. Goodrich Chemical's Akron, Ohio, plant, will become plant manager of the Company's new Henry, Ill., General Chemicals plant which is scheduled for completion in early 1958. He will be succeeded at Akron by **Edwin W. Harrington**, who is now director of rubber and rubber chemicals at the company's development center at Avon Lake, Ohio.

(Continued on page 196)

people

New vice-president for research and development at M. W. Kellogg will be **Alex G. Oblad.**

Oblad

Prior to joining Kellogg, Oblad was vice-president in charge of research and development and a member of the Board of Directors for Houdry Process Corp., Philadelphia.

Ronald R. Christian, formerly in the Product Development Department of Hagan Chemicals and Controls Co., Pittsburgh, Pa., joins staff of U. S. Steel's Applied Research Laboratory, Monroeville, Pa.

New chemical engineers in the Research Department of Air Products, Inc., are **Leo DiRicco, Willard L. Ent,** and **Albert M. Momenthy.**

New research associate at the Esso Research Laboratories, Baton Rouge, La., is **Kenneth A. Draeger,** a member of the Laboratories technical staff for the past ten years.

Frederick A. Gilbert is named president of the Westvaco Chlor-Alkali Division of Food Machinery and Chemical Corp. Gilbert will continue as president of the company's Becco Chemical Division. Also at Food Machinery and Chemical, **Franklin Farley,** formerly president of Westvaco Chlor-Alkali Division, will serve as management consultant to the Chemical Divisions. Before joining Food Machinery in 1954, Farley served for many years as vice-president of International Minerals and Chemicals Corp.

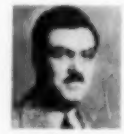
Harold C. Weingartner has joined the senior staff in the Engineering Division of Arthur D. Little, Inc., Cambridge, Mass. Weingartner comes to Arthur D. Little from Welling & Woodward, industrial consultants.

W. R. Grace & Co. has appointed **Francis J. Sergeys** vice-president in charge of development for its Research and Development Division.

Sergeys

Prior to joining Grace, Sergeys was general manager of Chemical Products Research and Development for Ethyl Corp., Baton Rouge, La.

Donald L. Katz, chairman of the Chemical Engineering Department, University of Michigan, was the lecturer for the second E. P. Schoch Series at the University of Texas. His subject was "Phase Equilibria at Low and High Pressures."



Katz

Promotions at Monsanto Chemical include appointment of **Joseph R. McCleskey** to the production department of the company's Plastics Division plant at Texas City, Texas. New members of the Monsanto staff are **Leon Cooper,** who becomes section manager of the applied mathematics section, Engineering Department, of Monsanto's Research and Engineering Division at St. Louis, and **Robert T. Kirkpatrick,** who joins the research department of the company's Inorganic Chemicals Division at Everett, Mass.

Jacobs Engineering Co., Pasadena, Calif., names **Stanley L. Krugman** as vice-president. Krugman was formerly chief engineer of the company in charge of process and plant design.

(Continued on page 198)

people

Albert H. Cooper is new general manager of American Industrial Chemical Co., a division of Amerace Corp. An authority on silica gels and silicates, Cooper was formerly manager of engineering research and development for Davison Chemical Corp. and served in similar capacities with Pilot Engineering Co. and Chemecon Corp. In the educational field, Cooper has headed the Departments of Chemical Engineering at the University of Denver, Bucknell University, and Pratt Institute.

Cooper

B. F. Goodrich Aviation Products' new rocket propellent research facilities at Rialto, Calif., will be directed by **Harold W. Catt,** formerly B. F. Goodrich general purchasing agent. **A. B. Japs,** previously director of chemical engineering research at the company's Research Center, Brecksville, Ohio, will be development manager at Rialto.

John W. McGovern has been elected president of United States Rubber Co. At the same time, McGovern was designated as chief operating officer of the company.

McGovern

Minnesota Mining & Manufacturing Co. appoints **A. O. Zoss** manager of manufacturing administration, Chemical Products Group. Before joining Minnesota Mining, Zoss, a specialist in the fields of vinyl polymer and acetylene chemistry, had been for more than two years manager of General Aniline and Film Corp.'s Linden, N. J plant.

Charles R. Jacoby joins the Engineering Research Staff of Michigan Chemical Corp., where he will be concerned with rare earth process studies.

Libby, McNeill & Libby announce election of **Robert M. Schaffner** as vice president. Schaffner, most recently general superintendent of the company's Eastern Division, will be in charge of laboratories and will head all research and quality control operations of the company.

Schaffner

Scott Turner chosen by four major national engineering organizations to receive their jointly-sponsored Hoover Medal for 1957. Donor societies are American Society of Civil Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers. Scott was formerly director of the U. S. Bureau of Mines.

The Annual Medal of the A.S.M.E., awarded for "distinguished service to engineering and science," goes in 1957 to **Llewellyn M. K. Boelter,** chairman of the Dept. of Engineering at the Univ. of Calif.

William Rudko will be plant manager in charge of the recently-expanded production facilities of Rubber & Asbestos Corp. in Bloomfield, N. J. Rudko was formerly plant manager at F. H. Maloney Co., Houston, Texas.

Joseph A. Palermo has joined the Univ. of Toledo faculty as associate professor of chemical engineering. For the past five years, Palermo has been a process development engineer for the Colgate-Palmolive Co.

Bettis Plant, Pittsburgh atomic power research laboratory operated by Westinghouse for A.E.C., announces appointment of **David Zucker** as performing engineer with the Nuclear Core Section.

Key staff promotions at Battelle Memorial Institute include: **Bertrand A. Landry** and **Richard J. Lund** to be assistant technical directors, and **David D. Moore** to be manager of the Institute's Department of Economics.

Mervin J. Kelly, president of Bell Telephone Laboratories, Inc., has been named general chairman of the business and industry campaign for the new \$10,000,000 United Engineering Center to be constructed on United Nations Plaza in New York City.

R. K. Turner appointed president of Bakelite Co. to succeed **George C. Miller,** who becomes president of Union Carbide Realty Co.

Jack Tielrooy, formerly vice-president in charge of engineering and development of Brea Chemicals, Inc., has established a consulting chemical engineering practice with offices in Fullerton, California.

(Continued on page 200)

people

Recently-elected vice-president of Bowen Engineering, Inc., is **Dexter A. Smith,** formerly manager of the Spray Drying Dept. of the Swenson Evaporator Co. Long active in the A.I.Ch.E., Smith served two years as chairman of the Chicago Section.

Smith

William Haynes, historian of the chemical industry and former business magazine publisher, has won the 1957 Dexter Chemical Corp. Award in the History of Chemistry.

Darrell L. Hunter appointed junior technologist in the Raw Materials Engineering Division of U. S. Steel's Applied Research Laboratory, Monroeville, Pa.

Swenson Evaporator Co. promotes **A. R. Downing** to post of manager of their Spray Dryer Department. Downing has been associated with Swenson Evaporator since 1942.

John J. McKetta, Jr., Univ. of Texas Chemical Engineering Department chairman, has been named to a two-year term on the Board of Trustees of Tri-State College, Angola, Ind.

Robert E. Frey, for the past six months assistant works manager for operations of Diamond Alkali Company's Painesville, Ohio, plant, has been named to the newly-created position of assistant works manager. In his new post, Frey will be concerned with employee and public relations as well as with operations.

New director of the Production Division for the A.E.C.'s Oak Ridge Operations will be **Charles A. Keller.** Keller first joined the national atomic energy program in June, 1946, when he was assigned to Oak Ridge as assistant declassification officer.

Edward A. Bertram becomes a vice-president of Yuba Consolidated Industries, Inc. This appointment follows five years as manager of the European Heat Exchanger Division of the Lummus Co.

Bertram

J. Kenneth Koster will be manager—construction for B. F. Goodrich Chemical Co., in which post he will supervise all new plant construction and major expansions of existing facilities.

Koster

New director of administration of Mellon Institute is **G. Arthur Webb,** who will head the General Administration Division of the Institute which embraces all engineering functions.

Clarence E. Davies, secretary of A.S.M.E., is named building coordinator of the new United Engineering Center to be erected on United Nations Plaza in New York.

A. Klinkenberg, A.I.Ch.E. member from Holland, is co-editor of a book in work by the Shell Group on "Static Electricity in the Petroleum Industry," highlights of which were recently presented at the Annual A.P.I. meeting in November. During his current tour of the U.S., Klinkenberg will also attend the A.I.Ch.E. Annual meeting in Chicago.

(Continued on page 206)

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Young men with advanced degrees in chemical engineering or at least three years' experience in process design of oil refining or chemical manufacturing facilities. Opportunities directly concerned with evaluation of research projects in the petroleum and chemical fields and design of new process units for Shell Oil Company and Shell Chemical Corporation. Located in the San Francisco Bay Area. Write giving education, experience, and personal history to Employment Supervisor.

SHELL DEVELOPMENT COMPANY
Emeryville 8 • California

CHEMICAL ENGINEERS

Opportunities in **Research and Development**
. . . . Equipment and Process Design
. . . . Process development work
. . . . Product improvement studies
. . . . New product development

American Viscose Corporation is a chemical process company that manufactures synthetic fibers, films, plastics, and related chemicals.

Openings are technically challenging and offer good advancement possibilities. Location is in Suburban Philadelphia.

Applications are invited from B.S. and M.S. chemical engineers with 1-8 years of experience.

AVISCO

Send resumes to:
Recruitment Director
AMERICAN VISCOSE CORPORATION
1617 Pennsylvania Boulevard
Philadelphia 3, Pennsylvania

CHEMICAL and INDUSTRIAL ENGINEERS

Hiram Walker & Sons, Inc.

Has excellent opportunities for YOUNG CHEMICAL AND INDUSTRIAL ENGINEERS in applied chemical engineering unit operations, process control and quality control.

Send Resume to

Hiram Walker & Sons, Inc.
Personnel Div.
1616 So. Washington Street
Peoria, Illinois

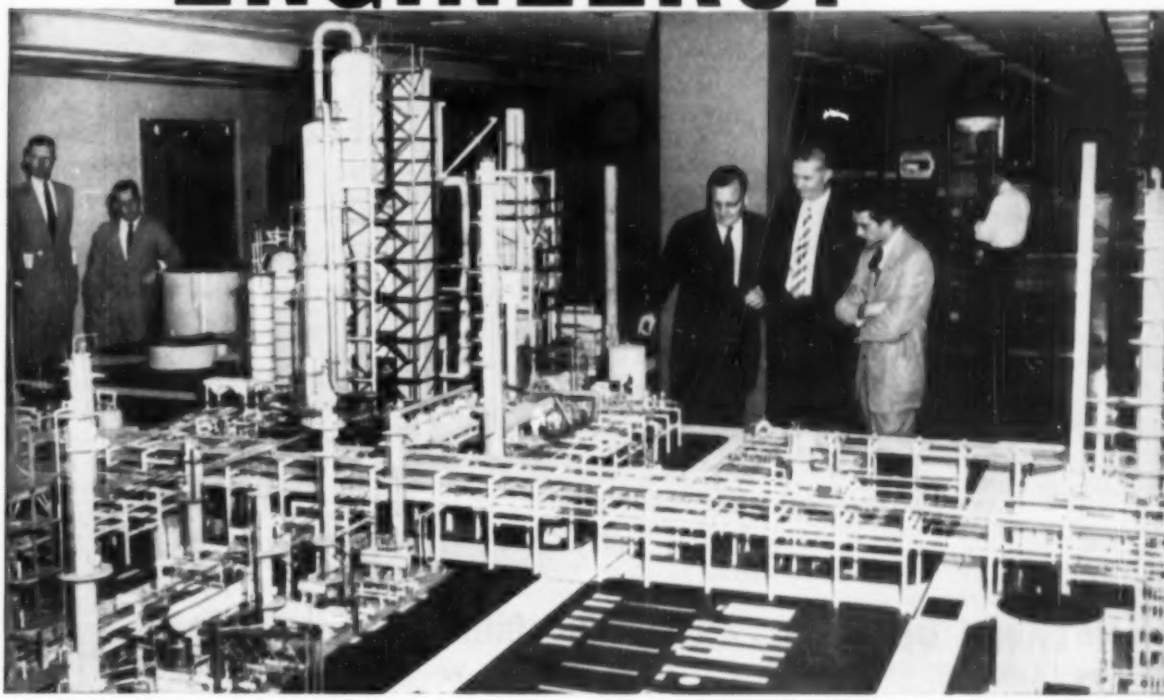
CHEMICAL ENGINEER

Attractive opening in our Research and Development Laboratory for a young man with a degree in Chemical Engineering. Some experience in progress development work or applied research would be helpful but not essential. International company. Send resume including salary requirements in confidence to Employment Manager,

The Nestle Company, Inc.,
Fulton, N.Y.

CHEMICAL ENGINEERS — Wanted for process engineering design work connected with pharmaceutical, organic chemical, and antibiotic production. Excellent opportunity for broad experience in the above related fields. Address all applications to Director of Personnel, Abbott Laboratories, North Chicago, Illinois.

WE NEED EXPERIENCED ENGINEERS!



Company engineering managers inspecting the scale model of the cat-cracker section of the new $34,000,000 Toledo refinery.

The Standard Oil Company (Ohio) is looking for chemical and mechanical engineers with one to five years experience in petroleum refining or related activities. Applicants should have the following educational background and industrial experience.

CHEMICAL ENGINEERS:

B. S. or higher degree and experience in development, pilot plant operation, process design, process trouble shooting, refinery process engineering, economic studies, or related work background.

MECHANICAL ENGINEERS:

B.S. or M.S. degree and experience in process equipment construction, design, inspection, or maintenance, petroleum product testing and field evaluation, or related work background.

Age range 22-32

Salaries commensurate with experience and level in organization. Advance on merit basis.

If you can qualify and are looking for a permanent job with a growing and secure midwest company, write, giving full information on education, industrial experience, military experience, and personal data to C. A. Bruggers, 1737 Midland Building, Cleveland 15, Ohio.

THE STANDARD OIL COMPANY
(OHIO)

RESEARCH ENGINEERS
Extractive Metallurgists
Chemical Engineers
Chief Chemist

New Pilot Plant and Laboratory
for
extraction of nickel from oxide ores
Operated for U. S. Government
by subsidiary of
National Lead Company
at Nicaro, Cuba

Send resume to:

Director, Res. & Dev. Division

NICKEL PROCESSING CORPORATION
4 Cherry St., Montclair
New Jersey

ENGINEERS

To work in an expanding research division. Men with advanced degrees preferred—for fundamental work in chemical and mineral engineering processes. For further details write to:

M. C. Rohm, Employment Section
Allis-Chalmers Mfg. Company
Milwaukee 1, Wisconsin

SITUATIONS WANTED
A.I.Ch.E. Members

CHEMICAL ENGINEER—Age 32, M.S.Ch.E. 1951. Capable, industrious. Three years supervisor organic synthesis, three years process development; desire responsible, challenging position with advancement opportunity in production supervision or process development organic chemicals; central N.J. preferred. Box 5-11.

CHEMICAL ENGINEER — B.S.E.(Ch.E.); M.S., four years' experience. Desire position in U.S.A., Canada or England with consulting firm or in design, development, research with industry or institute. Native of India. Age 33, married, one child. Box 6-11.

PRODUCTION MANAGEMENT ENGINEERING—M.Ch.E. Fifteen years' experience in chemical food processing and aerosol packaging plants. Plant manager, process engineer, process evaluation and development, production supervision. Seeking responsible position in production management. Present Salary $11,000. Box 7-11.

CHEMICAL ENGINEER—M. S. Twenty years' experience petroleum refining, process engineer, development and supervision. Desire position with progressive company. Box 8-11.

(*Continued on page 206*)

An Invitation To Join ORO...Pioneer In Operations Research

Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

At ORO, a civilian and non-governmental organization, you will become one of a team assigned to vital military problems in the area of tactics, strategy, logistics, weapons systems analysis and communications.

No other Operations Research organization has the broad experience of ORO. Founded in 1948 by Dr. Ellis A. Johnson, pioneer of U. S. Opsearch, ORO's research findings have influenced decision-making on the highest military levels.

Our computer laboratory is equipped with the 1103-A Univac, the "Cadillac" of computers. Encompassing 1200 sq. ft., it is leased at a cost of $40,000 per month. ORO's professional atmosphere encourages those with initiative and imagination to broaden their scientific capabilities. For example, staff members are taught to "program" their own material for the Univac computer so that they can use its services at any time they so desire.

ORO starting salaries are competitive with those of industry and other private research organizations. Promotions are based solely on merit. The "fringe" benefits offered are ahead of those given by many companies.

The cultural and historical features which attract visitors to Washington, D. C. are but a short drive from the pleasant Chevy Chase suburb in which ORO is located. Attractive homes and apartments are within walking distance and readily available in all price ranges. Schools are excellent.

For further information write:
Professional Appointments

OPERATIONS RESEARCH OFFICE
ORO The Johns Hopkins University
7100 CONNECTICUT AVENUE
CHEVY CHASE 15, MARYLAND

SITUATIONS WANTED

A.I.Ch.E. Members

(*Continued from page* 205)

PROJECT ENGINEER—M.S. Bus. Adm., B.S. in chemical engineering. Age 40, with twelve years' engineering and managerial experience in petroleum industry and six years in atomic energy programs with complete project responsibilities. Techno-economic study experience. Box 9-11.

PROJECT ENGINEER—B.Ch.E., Registered Engineer (N.Y.). Over ten years' experience in the design and operation of chemical plants and oil refineries, including planning, piping, cost estimating, heat transfer equipment, pressure vessels, and process development. Graduate and in-training courses in computor programming and nuclear engineering. Prefer position with large company in midwest or east. Box 10-11.

TECHNICAL EVALUATION-LIAISON ENGINEER—Ph.D. in Ch.E., 1953. Five years of evaluation, design and project planning in petrochemical and inorganic fields. Desire challenging position on planning staff. Domestic or foreign. Box 11-11.

HEAT TRANSFER ENGINEER—M.Ch.E. with twelve years' experience in specification, rating and design of power plant and refinery heat transfer equipment. Desire responsible position in this or allied industry. Married, children. Presently employed. Box 12-11.

CHEMICAL ENGINEER—B.Ch.E., M.S.Ch.E.—1950. Eight years' organic production, process improvement and start-up experience—batch and continuous; four years of organic process design. Age 38. Desire position with good opportunities. Minimum salary $10,000. Box 13-11.

CHEMICAL ENGINEER—B.S.Ch.E. 1951. Family. Six years' experience including refinery process control, design and economics, overall refinery coordination, and recent experience stored program computers and Operation Research methods. Member Tau Beta Pi, Sigma Tau, registered professional engineer. Desire position entailing responsibility and advancement opportunities. Preferable location Latin America. Fluent Spanish. U.S. Citizen, previous overseas experience. Box 14-11.

CHEMICAL ENGINEER—B.S.Ch.E., 1949. Age 29. Seven years' experience in development, plant start-up, production. Looking for better opportunity and higher degree of responsibility, plus commensurate return. Northeast location preferred. Box 15-11.

CHEMICAL ENGINEER—M.Ch.E., Age 37. Experienced in research, development, process engineering and administration in petroleum, heavy chemicals, equipment manufacturing, and nuclear energy. Licensed engineer. Desire responsible position. Salary $10-12,000. Box 16-11.

CLASSIFIED SECTION RATES

Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 10th of the month preceding publication.

the chemical engineer in

MARKETING

Robert B. Scrimgeour appointed manager of the Chemical Sales Department for the Pfaudler Co., Rochester, N. Y. Scrimgeour will be responsible for overall chemical equipment sales and will assist with special designs and additional customer requirements.

Scrimgeour

Union Carbide Chemical Co. has named **Robert W. Gaines** to its Fluorocarbons Technical Service Staff. Gaines will work primarily in the field of aerosol propellants and pressure packaging.

John C. Geniesse appointed by the Atlantic Refining Co. as manager of its newly-created Product Development and Technical Services Division of the Marketing Department. Geniesse was previously a divisional director in the company's Research and Development Department.

Geniesse

John T. McDonnell and **James K. Sorgini** have joined the Chemical Marketing Group of the Petrochemicals Department, Gulf Oil Corp. McDonnell will be located at Houston, Texas, and Sorgini in the general office in Pittsburgh, Pa.

Jerome S. Stanford has joined Olin Mathieson Chemical Corp. as executive assistant to the vice-president for sales of Olin Aluminum.

CANDIDATES FOR A.I.Ch.E. MEMBERSHIP

(*Continued from page* 191)

Ohio. Wofchuck, Joseph, *Brooklyn, N. Y.* Wrixon, George F., *Brooklyn, N. Y.* Wuensch, Edward M., *Staten Island, N. Y.*

• Yanosak, John D., *Crownsville, Md.* Yavitz, Eric A., *New York, N. Y.*

• Zervoglos, George N., *Haverhill, Mass.* Ziesel, Leon, Jr., *Chatham, N. J.* Zimberg, Walter M., *Le Roy, New York.*

Affiliate Member

• Bonner, Robert O., Jr., *Kingsport, Tennessee.*

• Harris, Malcolm R. *Newton Hlds., Mass.* Holden, Lawrence N., Jr., *Pittsburgh, Pa.*

• Sattar, S. A., *Daudkhel, Pakistan.* Shields, Alfred D., *Kingsport, Tennessee.* Snizek, Paul Richard, *Niagara Falls, N. Y.*

SAVE THOSE BACK ISSUES

Every so often an unprecedented demand for a particular issue, or an unexpected influx of new subscribers and members puts the editor in the embarrassing position of running out of copies of Chemical Engineering Progress. This has happened several times in our short history and if members have copies of any of the following issues, we would be glad to purchase them. The issues which we need and for which we will pay 75 cents each are: July, Aug., Oct., Nov., 1950; Nov., 1952; Feb., 1953; May, Dec., 1954; Jan., May, 1955; Jan., Mar., 1956.

All these issues were overprinted to a great extent, but because of features and other demands, single copy sales, etc., they were completely exhausted in a short time.

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New York 36, New York

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Dallas 28—Richard E. Hoierman, Dist. Mgr., 9006 Capri Drive, Dallas 18, Texas. Davis 7-3630.

Birmingham 8, Ala.—Fred W. Smith, Dist. Mgr., 1201 Forest View Lane, Vesthaven, Birmingham 9, Ala., TRemont 1-5762.

news and notes of A.I.Ch.E.

Slogan & symbol contest . . . Now it can be told—now that the winners of the Slogan & Symbol Contest have been officially notified . . . Altogether there were 278 slogans submitted & 154 symbols . . . Out of these was picked as the winning slogan, "Science and Industry in the Service of Man" . . . This was the slogan submitted by Clay Lewis of Georgia Institute of Technology . . . The winning symbol was suggested by R. L. Rorschack, who is with Warren Petroleum Corporation as a chemical engineer . . . The judging committee met during August & from the large list selected two slogans & two symbols, which were sent to the Fiftieth Anniversary Committee for final choice & C. G. Kirkbride reported for the committee at the Baltimore meeting . . . so our congratulations to the winners & a check for $250 to each.

Directory . . . A new directory was issued during October by the Secretary's Office, the product of quite a bit of labor this year, for its origin is the new I.B.M. system now operating in our offices . . . The new directory is, of course, larger than ever & it is a basis for a new system for turning out directories . . . We hope at the beginning of each year to run off from our punched-card records a list of members' names, positions, interests, etc., & turn this over to a Justowriter photo-offset printing organization to reproduce at less cost than was required for the former type-set, letterpress directory . . . Members, if they want a directory, should just drop a card to the Secretary's Office & one will go out at the first possible moment . . . Also, members now, more than ever, must keep the Secretary's Office notified of changes in address, job title, interests; of promotions within the company; etc., because the information currently in our file will be the basis of new directories.

Student Chapter Bulletin . . . Council appointed W. E. Keppler of the Merck organization to be the Editor of the Student Chapter Bulletin . . . this has not been issued during the school year of 1956-57, but Bill is going to get the book underway this winter so that we will continue A.I.Ch.E.'s news to the students. **Committee chairmen for 1958** . . . Admissions, A. Jonnard . . . Awards, E. R. Gilliland . . . Career Guidance, Raphael Katzen . . . Chemical Engineering Education Projects, R. C. Kintner . . . Accreditation, C. C. Monrad . . . Equipment Testing Procedures, C. H. Brooks . . . Membership, E. Madison Jones . . . Pollution Control Engineering, R. F. Weston . . . Professional Development, Jerry McAfee . . . Professional Legislation, C. E. McCulloch . . . Program, E. R. Smoley . . . Publications, K. N. Kettenring . . . Public Relations, Theodore Burtis . . . Research, W. C. Schreiner . . . Standards, J. C. Lawrence . . . Student Chapters, J. G. Knudsen . . . Symbols & Nomenclature, F. M. Tiller. **E.C.P.D. representative** . . . The vacancy in our representation on E.C.P.D. caused by the death of our Treasurer George Granger Brown was filled by Council's action in appointing J. H. Rushton our official nominee. **Student Chapter Award** . . . A new award to recognize the outstanding achievements of some of our student chapters & their counselors as judged by the number of their seniors who join the A.I.Ch.E. upon graduation has just been created . . . this was worked out with the Membership & Student Chapters Committees. **Council** commended the **Heat Transfer Conference** at Penn State this year & expressed its gratitude to C. H. Brooks & J. N. Addoms of A.I.Ch.E. plus the officers of A.S.M.E. who worked to make the meeting a success. **Welcoming new members** . . . A new idea is being tried at the meetings of A.I.Ch.E. . . . a separate room is set aside in which Council members greet new members of A.I.Ch.E. who are attending their first meeting . . . This way it is felt that new members will feel more at home &—equally important—will realize that the representatives on Council are there to serve & help them. **Research Committee** . . . The projected research program of Warren Schreiner's committee, reported in this column last month as concerning vapor-liquid equilibrium, will actually investigate the fundamentals of liquid-liquid extraction. **Got a Gripe?** . . . Communication from Council to members is difficult & quite often communication from members to Council is more so . . . The old slogan "the customers always write" isn't always true, but here is an open & standing invitation for members of A.I.Ch.E. who feel strongly—or even mildly—about chemical engineering problems either to write to the Secretary or any member of Council or any officer or to air their opinions at local meetings . . . Council needs the ideas of members & for those thousands of people who have joined in the past few years this explanation of how to present ideas to the membership perhaps is needed & may be welcome. **See you in Chicago in December.**

F.J.V.A.